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EDITORIAL.

ITEMS AND NOVELTIES.

Shaw's Planer Bar.—The invention herewith illustrated is designed to enable ordinary planing machines to perform the work of shaping and slotting machines, and to plane through, under, and over work through apertures, and between high projecting parts, in a thorough manner, never heretofore attempted on a planer, and excels the slotting and shaping machine, by reason of the extra length of work it will penetrate. A 5-ft. planer machine, provided with one of these bars at trifling cost, will plane through twenty inches, thus penetrating to a greater depth than a far more expensive shaping machine. A 12-ft. planer, provided with one of these bars, will plane through four feet of work. It will operate on a long or short stroke, and the ordinary feed of planer controls the feed of bar.

In brief, the planer bar will reach through work on planing machines, and thus serve to perform a large proportion of the labor of slotting and shaping apparatus, at, of course, a materially decreased expense. It consists of a heavy shaft A, which rides upon centres B. On this shaft the bar C is pivoted; so that by this mode of connection a universal joint is obtained, and the outer end of the bar rendered capable of motion in all directions. Near the centre of the bar is a pivoted box D, from which a pin projects, which is securely

fastened to the tool-post and carriage. The bar is therefore subject to the movements of the latter, and is regulated by the ordinary feed motion of the planer. At E the tool end is represented as operating on the inside of a wide casting.

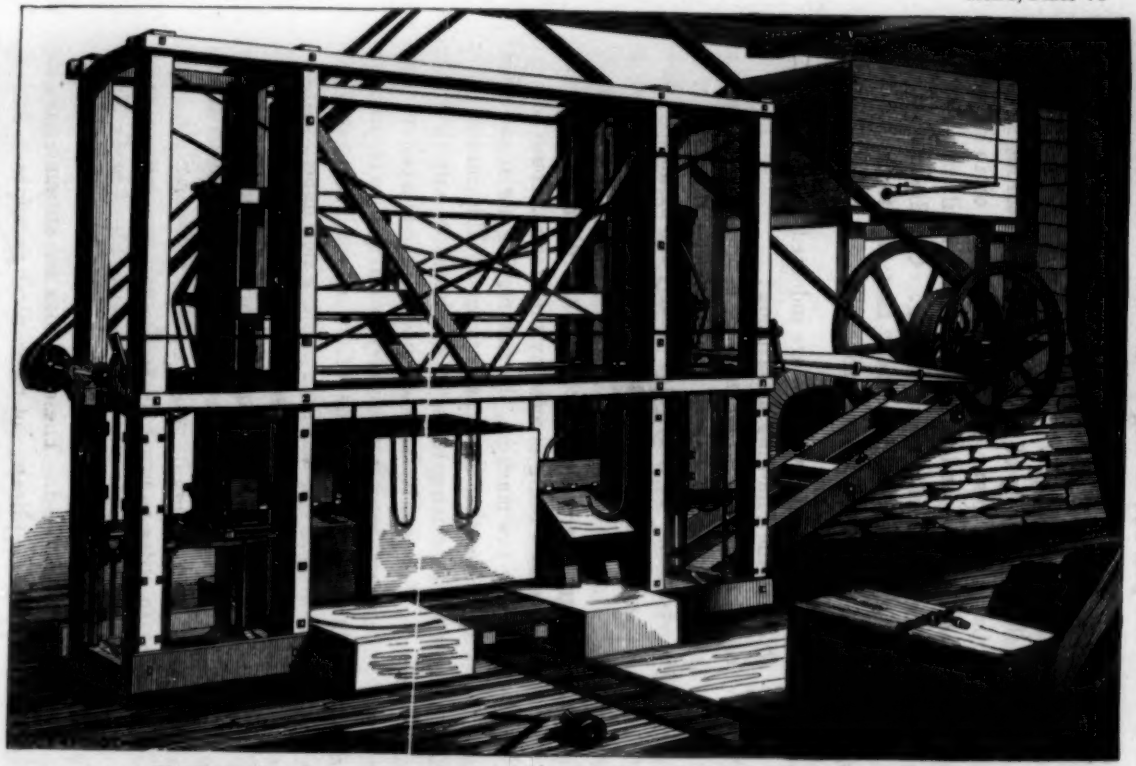
It is claimed that the ability of the device to reach through work is unlimited, and that it will plane one third the length of the planer; while its action being of an end-thrust character, it will cut all that the machine is able to pull without chattering. Our illustration presents so enlarged a view of the invention, that any farther details here are unnecessary to insure its comprehension.

Diamond Saw Machinery.—We are indebted to the *Manufacturer and Builder* for the following description:

A working model of Young's Diamond Saw is on exhibition, and in daily operation at the present Fair of the American Institute in its most improved condition. It illustrates clearly the distinct features of the invention, and cuts an astonishing amount of stone for the size of the machine.

The annexed engraving represents one of the diamond saws, such as have been and are now being erected by the Messrs. Young. It is a so-called reciprocating saw machine, the saw moving horizontally and attached to a frame like other stone saws; but in this machine diamonds are employed as cutting tools, in combination with the steel blade as a guide. The diamonds are set in "cutter blocks" at intervals upon the blade, and work horizontally as a true saw in the stone set beneath. Three distinct movements are applied in the cutting process; first, the ordinary to-and-fro motion, which impels the saw; second, a lift motion, by which the saw, after cutting the stone, is lifted in the cut from an eighth to a quarter of an inch, to enable it to return to its starting point without roughing out the diamonds; third, a graduated feed motion by which the saw is lowered after each stroke in cutting, in order to bring the tools again in contact with the stone. Each of these different motions is susceptible of being altered and arranged to adapt itself to the character of the stone—hard or soft—and to the feed desired. These motions are all automatic, and obtained by the simple application of mechanical principles. Indeed, it is difficult to decide which to admire most in this machine, the ease with which it works, the large amount of its productive power, or the simplicity of its construction. In regard to the expense of running such a machine, we ought not to omit the statement that the resist-

Items, Plate V.
Journ. Frank. Inst. Vol. LXVI.



YOUNG'S RECIPROCATING DIAMOND SAW MACHINE.

ance of any stone under operation, is toward the diamond saw somewhat greater than it is toward an ordinary saw of iron used with sand. A given power cannot therefore run as many diamond saws as it can move ordinary saws. But in compensation, while an ordinary saw cuts on an average 15 inches of brown stone in a day, the diamond saw will do as much in half an hour.

It may be supposed that such saws may be liable to get out of order, but this is by no means the case; they work steady day after day, if only the diamonds are well set in their fastenings, and if at last one of them is, by any accident, loosened, it is at once caught by a wire sieve, and can be reset with little labor, and by any mechanic after a day's teaching.

Many of these machines are in practical daily use in this city, and in other localities.

A "Self-Breaking Hoisting and Lowering Machine."—A working model of this apparatus was shown and explained by the inventor, Walter Hart, of Philadelphia, at the last meeting of the Institute. Its construction is of a novel character. It performs work of the usual kind and also that not hitherto accomplished by any other single machine.

Its construction consists of parts so arranged that the weight of the object which is being moved by it, acts automatically as a stop to its own motion; the release from that stoppage, and such freedom of movement as may be desired, are effected by means of simple and easily managed devices. The breaking gear is a specially novel one. It acts directly with gradual though rapid effect on the rope or chain. The inventor claims and practically demonstrated that it moves two objects at one and the same time, each independently of the other; that it moves a lengthy object at any desired angle, changing that angle while hoisting or lowering it; that its workings are under thorough control, and the dangerous features arising from a descending weight are reduced to the breaking of the ropes or chains.

As a much called for means of safety in lowering boats from vessels with regulated speed and with an even keel, Mr. Hart explained and showed that a boat filled with its freight of persons, food, etc., could be raised and lowered through the aid of his machine by two men only, and that it was not possible to lower one end faster than the other. It can also be attached to suspended platforms with like effects, the evenness of movement both in boats and platforms being

unaffected by the weight being heavier towards or at one end than the other. It can be fastened to the decks of vessels and to the heels of derricks, cranes and shears.

A Gas and Water Cut-Off.—This invention, known as the Seal and Brook's patent, was exhibited at the last meeting of the Franklin Institute, and is designed, according to the inventor's statement, to avoid the overflowing, freezing and bursting of water pipes, and to control the supply of burning gas.

The accompanying cuts represent the essential parts of the device, which consist of a lever and gauge (Fig. 1) to be placed in some conveniently accessible spot in any room of the house, and a spring valve (Fig. 2) in the cellar, the latter con-

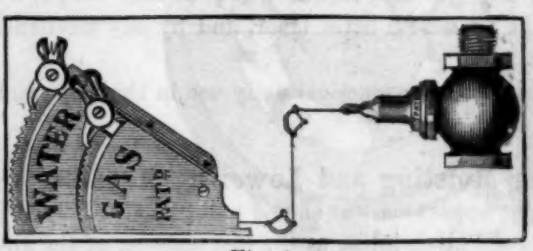


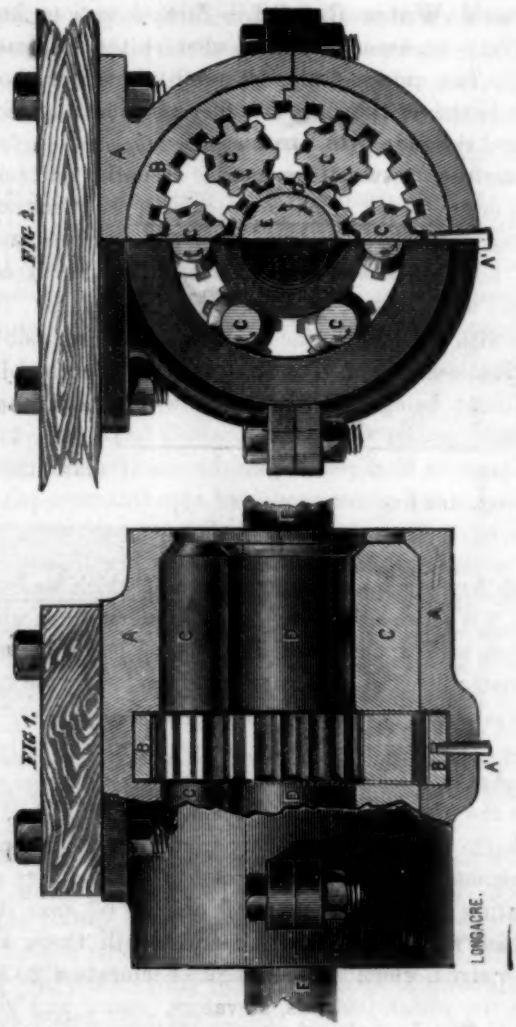
Fig. 1

trolled by wires leading from the gauge. By regulating the valve opening, the flow of water and of gas through the meter may be controlled to a nicety, or the pressure may be removed entirely from the gas meter, pipes and fixtures during the day, if the certainty of avoiding all leakage is desired. In cases of accidents by fire or derangement of pipes, the complete control of the pipes afforded by this device is particularly valuable. The utility of the contrivance is too obvious to need further comments.

Fig. 2.

An Anti-Friction Journal—(JAMES ECCLES, Philadelphia).—The invention herewith illustrated is universally applicable to shafting, water wheel journals, elevators, steam and city passenger and freight cars, vehicles of every denomination, iron and steel rolling mills, steam engines of every kind, machinery of almost every kind, grind-stone journals, pivot and draw bridges, and other similar uses; and it is claimed that it will work under any pressure or speed, practically without wear, and without the use of a lubricant.

Journals and shaft bearings, made of various kinds of metal or other materials, as used at the present time, are too well known to require any description in this paper.



Anti-friction rollers have been applied in various ways for at least a half century, but none (to the knowledge of the writer), have been successful. In many cases friction has been reduced to some extent by their use, but only for a limited period; for, after brief

trial, they became useless through unequal wear, and consequently were abandoned.

The frictional journal box is made by forming gear teeth or cogs on the journal itself, or on an outer bush placed thereon, and gearing these teeth with corresponding teeth formed on a series of rollers, which gear into an annular geared wheel placed or cast within the journal box. The width of all the teeth should be about equal to one-third the length of the journal. The *pitch lines* of said teeth are parallel to, and coincide with, the respective *bearing* surfaces, so that the various surfaces may roll on to and around each other without any abrasion or friction. When the journal revolves, the bush rolls on the bearing surfaces of rollers, which then roll around the inner periphery of box. The whole may be made of cast steel or other metal, and will work with or without being lubricated. The two engravings herewith given show the device in front and side section.

This construction is claimed to be a practical frictional journal box, will work without being lubricated, and will last for an indefinite period of time.

The advantages to be derived from the use of a frictionless journal or shaft bearing, are too numerous and apparent to require any comment.

Guns and Armor.*—The biggest gun of which we have hitherto heard is the "Woolwich Infant," of 35 tons weight, which fires a 700-pound shot with a charge of 110 lbs. of powder; and the shot from this monster piece of ordnance could perforate the turret of the famous "Devastation" at any distance up to 500 yards. The armor plating of the "Devastation" is 14 inches in thickness, but an additional two inches in thickness would, it is said, render the vessel shot-proof against the biggest gun in the world. The English War Department has hitherto advanced cautiously from guns of 12 tons weight to 18, 25, and ultimately to 35 tons in weight; but they are now said to be contemplating the construction of one of 60 tons, the powder charge for which will weigh 200 lbs.; and it will throw a shot over half a ton in weight, which will be able to perforate a 20-inch turret.

Hardening Steel.—Amongst the American patents recently issued is one relating to the hardening of steel wire or thin steel. The process is as follows: The wire or thin steel is heated to a red

* Quart. Journ. of Science, iii, 539.

heat by any of the known processes for uniform heating. It is then taken from this heat, and subjected immediately to a strong blast of air or gas, so as to cool it rapidly, varying the temperature of the air-blast and its degree of velocity, as may be required to give to the steel the requisite degree of hardness. After this the substance may may be tempered as desired for the purposes to which it is to be employed. The process may be made continuous, so that while one portion of the material is being heated another portion is under the blast of air, while another portion may be in the tempering.

Coal Cutting Machinery in American Mines.—The following information concerning the Brown "Monitor Coal Cutter," in use at the "Coal Brook Mines" of Messrs. Niblock, Zimmerman & Alexander, at Brazil, Indiana, concerning which several descriptive articles have appeared in the technical press, may be of interest:

BRAZIL, IND., Oct. 9, 1873.

Editor of Journal of Franklin Institute:

DEAR SIR:—The Coal Cutter has been working pretty much all summer in our No. 3 mine, and has proved itself a practical success. Not merely experimental cuts have been made, but it has been in operation day after day, and has already mined hundreds of tons. Like all novelties, it will require increased experience on the part of the operators handling it, before its best results can be brought out.

Owing to the limited space prepared for its operations, it, as yet, has only been running about one-fourth of its time, as it must wait till the coal is taken away. More room, however, is being prepared, and in a short time it is hoped that its full capacity will be tested. It is expected that each machine, with seven men, will mine fifty tons each shift of ten hours, or about the output of twenty miners working with the pick.

I have been gathering some facts together with the intention of preparing a paper to be read before the Am. Inst. of Mining Engineers, at the Easton meeting, but fear I will hardly be able to do so now, as my time is much occupied. It will, however, afford me pleasure to keep you posted from time to time as to the workings of the cutter. I am yours, very truly,

JNO. S. ALEXANDER.

The Illinois and St. Louis Bridge.—The latest information concerning the work upon this structure, as derived from local sources, is the following:

During the past week 79 tubes were put in position, making in all 612 which are in place. As the whole number to be contained in the structure is 1012, only 400 are now remaining. Yesterday the two outer ribs of the first span were completed, with the exception of placing the connecting tube in each of the four strands. They are ready to put in, and the couplings are fitted and lying on the bridge beneath. Early to-morrow (Oct. 20th) they will be put in place and keyed up, and the first span will be an accomplished fact. As soon as that is done there will be no further use for the heavy wooden scaffold now encumbering the span, and it will be removed as speedily as possible, thus affording a view of the finished structure. On the west side of the east pier six lengths of tubes have been placed, and the same number on the east side. On the east abutment the arch has been built out seven lengths, or a distance of eighty-four (84) feet. The prospects are that the spans will all be completed before the first of January next.

The tunnel which forms part of the western approach is making rapid progress. The excavations are nearly completed, and the arching proceeds at the rate of nearly 400 feet per week.

Fastening Rubber to Metal.—As rubber plates and rings are now used almost exclusively for making connections between steam and other pipes and apparatus, much annoyance is often experienced by the impossibility of effecting an air-tight connection. This is obviated entirely by employing a cement, which holds equally well to rubber and the metal or wood. Such cement is prepared by a solution of shellac in ammonia. This is best made by soaking pulverized gum shellac in ten times its weight of strong ammonia, when a shining mass is obtained, which, in three or four weeks, will become liquid, without the use of hot water. This softens the rubber, and becomes, after volatilization of the ammonia, hard and imperviable to gases and fluids.

A Combination Tallow Cup.—(Davis & Dubois, manufacturers, Philadelphia).—The object of the invention herewith illustrated is a steady or continuous lubrication of the cylinder and slide valves of a steam-engine, thus preventing all wear of the working parts and economizing power without the usual waste of lubricating material. It consists of a combination tallow cup, and is claimed to be equally well adapted to marine, stationary and locomotive engines, and also

to afford results in every way satisfactory, during the period in which it has been in use.

In the sectional view annexed, A is the main reservoir, and B an auxiliary reservoir or charger; C is the main valve connecting directly with the cylinder, and D is a secondary valve, closing communication with the reservoirs, A and B. These valves are operated by handle E. F is the feeding valve, closed when main valve, C, is opened, and actuated by the wheel, G, serving to regulate the opening, H, in the stem, I. J is the inlet funnel, with valve-seated plug. K is an air-valve, to give vent while filling reservoir A.

The main valve, C, and stem valve, F, being closed by means of handle, E, and wheel, G, open valve K, and unscrew plug J; the reservoirs A and B are then filled with tallow, when valve K is closed and plug J replaced. By opening valve C, which closes valve D, the tallow in charger B is allowed to pass into the cylinder previous to starting the engine. When not used as a self-acting lubricator, the same operation of valves C and D is performed at intervals.

To render the action of the cup continuous, the valve F is opened (valves C or D being closed), when the steam, passing up through the stem I into the reservoir A, condenses and falls to the bottom, raising the tallow to a level with the openings H, from which it is sucked into the cylinder by every stroke of the piston as long as the supply of tallow remains. The reservoir is left filled with distilled water, which is let through the cylinder after stopping the engine by removing plug J and opening valves C and D. In case of any foreign substance entering the reservoir, it may be blown out while the engine is in motion, by allowing the steam to rush through the plug funnel.

Among the other advantages claimed may be noted strength and cleanliness, together with simplicity of construction; it is also stated that the device is steam-tight, precluding leakage, and thus dispenses with the usual means employed to absorb the waste. It may be used as an injector at stated intervals, or, by arranging the valves as above described, as a self-feeder. The cup is claimed to require filling but once a day to feed regularly, and to be economical in its expenditure of the lubricant.

The manufacturers state that it has elicited favorable testimonials from many leading engineers and master mechanics, and that its efficiency, in every respect, has been thoroughly demonstrated.

Irrigation and Drainage.—By D. S. HOWARD, *Mech. Engineer.*—There are two kinds of irrigation, natural and artificial. The obvious benefit of the former upon vegetation suggested, in the earliest ages, the necessity of supplying cultivated lands, in many countries where rains are not abundant, with water by mechanical means. The effect has been so universally beneficial that artificial irrigation has been adopted in all climates.

It has been ascertained that the more water disposed of by evaporation and proper drainage, the more productive the lands.

The absorbent and dissolving power of water for many gaseous and solid matters enables the falling rain to gather them from the atmosphere and soil, and to deliver them to the plants.

These considerations plainly require a system of irrigation that will furnish means to apply the water as nearly like rain as possible. This has been attempted, in a primitive manner, by the use of the hand watering-pot; the force-pump, worked by hand; and, in isolated cases, where a fall of water could be obtained to furnish the required power, a more effective manner of applying the water, through hose and sprinkler, has been resorted to, with proportionately good results.

The accompanying cut represents an irrigator and roller combined, a machine calculated to supply a long-needed improvement over the old laborious methods of hand-power irrigation, and capable of general application in localities not favored by nature with a plentiful and available supply of water, so situated as to furnish power to distribute itself.

A is a hollow cylinder, of wrought or cast iron, so arranged in the frame B, which is made of tubing, as to revolve on hollow, water-tight bearings, at both ends. The gear-flange, C, is attached to either end, the teeth of which engage with a pinion, D, which in turn gives motion to any suitably arranged gearing, to impart proper speed to the pump, E, attached to the frame over one of the bearings of the roller, A.

The pump, E, may be worked directly as a water pump, by which the water may be forced to any required height, and scattered to a considerable distance over any surface on either side of the track of the roller; or it may be so constructed as to be worked as an air-pump, to force air into the cylinder with a pressure sufficient to drive the water out with the necessary power to accomplish the same object. This will provide also for distributing liquid and powdered manures, and sprinkling plants and trees with poisonous solutions and powders, for the destruction of injurious insects, without injury to the working parts of the pump.

These machines may be built of any desired capacity, from the hand garden roller, for the horticulturist, to the largest and heaviest

machines, operated by steam, for the rolling and sprinkling of streets.

When used as a roller alone, the weight may be perfectly adjusted by the amount of water retained, and the gearing disengaged by a lever, not shown in the engraving, actuated by the foot of the operator.

This feature of the machine will be appreciated when the practice of rolling crops with an adjustable weighted roller, adapted to the condition of the soil, shall become common.

The tubular form of construction not only increases the water capacity of the machine, but adds to its beauty and strength, as well furnishing a ready means of attaching hose at any most convenient point for effective use.

It is proposed to mount upon this frame a globular air-chamber, that shall have all its connections with the cylinder beneath water, when the machine is filled, which the hollow construction readily admits, the chamber to be used as a receptacle for storing compressed air, the machine while in motion charging itself with a power that can be used to eject a large portion of its contents when stationary, which will prove useful in applying poisonous fluids to the foliage of trees, and in extinguishing fires.

Spontaneous Combustion.—In a paper on the "Ignition of cotton by saturation with fatty oils," Mr. John Galletly communicates some information confirmatory of the generally received popular opinion regarding the spontaneous kindling of cotton and other open combustible substances which may happen to have imbibed animal or vegetable fatty oils.

The apparatus employed consisted simply of a box, in which the cotton saturated with the oily substances was placed, and the temperature then gradually raised in some cases to 130° F., the temperature which a body acquires by lying exposed to the vertical rays of the sun; and in others to 170° F., about the heat attained in the neighborhood of a steam-pipe, a heated flue, or in front of an open fire.

With boiled linseed oil the author found that shortly after the material had reached the temperature of his warm chamber (170°), the thermometer began to rise—from 5° to 10° every few minutes—so that in 75 minutes from the time the box was placed in the chamber, the heat indicated was 350° Fahr. At this point, smoke issuing from the box indicated that the cotton was in a state of active com-

bustion; and on returning it to the free access of the air, it burst into flames. In another similar experiment, the temperature rose more slowly, but reached 280° Fahr. in 105 minutes, when, from the appearance of smoke, it was plain that the cotton was burning; and the whole mass was soon in a flame on being placed in a current of air. Raw linseed oil was found not to cause ignition of cotton so readily as the boiled oil, but under conditions similar to those of the above described experiments, active combustion was going on in one case in four, and in another in five hours. With rape oil under the conditions of the first experiment, the result was that the box and contents were found in ashes in ten hours—(the box being put up at night, the result was only observed in the morning.) Olive oil caused active combustion within five or six hours. With castor oil, the contents only charred on the second day of the experiment. Lard oil, (sp. grav. ·916), produced rapid combustion in four hours. Seal oil, (sp. grav. ·928), the same result in 100 minutes. Sperm oil gave negative results.

The author, as the result of his work, advances the opinion, from a comparison of raw linseed with lard and seal oils, that the statement is not altogether correct that "drying oils are more liable to spontaneous combustion than non-drying oils; and that the rate at which oxidation takes place does not depend chiefly on the presence of small quantities of putrifiable matters; but rather upon the particular oleine- or liquid fat they contain.

The results of the experimental trials are stated to have been remarkably uniform. The author states that the ignition of cotton can be calculated on for any oil with about the same certainty as the point at which sulphur or other combustible matter inflames in air.

The heavy oils from coal and shale were found to effectually check the phenomenon above described; for when mixed with the oils above named, they gave no indications of heating whatever at 170° Fahr.

In view of the vagueness of definite information concerning this subject, which is a matter of importance to all who are engaged in manufactures employing these materials for any purpose, any systematic contribution to our knowledge of the conditions under which these oils and others may cause ignition, is of very direct interest.

The Utilization of Waste Products.—In an eloquent address delivered at the opening of Pardee Hall, Prof. R. W. Raymond discourses in the following terms upon the subject of our heading:

"Some one has well said that the utilization of refuse is the measure of civilization. That which the alchemists sought in vain their descendants are finding step by step, the 'Philosopher's Stone,' which will turn the most despised substances into gold. The illustrations of this are innumerable. I must be content with one or two. Few forms of refuse were more troublesome to dispose of, a few years ago, than the coal tar which accumulates in the manufacture of burning gas. At first it was used only as a rude kind of paint for iron, etc. Afterwards it was distilled, and yielded a volatile oil, with which Bethel impregnated wood to preserve it from decay. Then it was found that one of the distillates was a good material for removing spots and stains from cloth. But all these applications were found inadequate to dispose of the great quantity of tar that accumulated. Then came the grand discovery aniline, enriching the world with new and brilliant colors; and now even the refuse of the aniline manufacture yields anthracine and alizarine (artificial madder), the discovery of which is one of the most important events of the day, revolutionizing a great industry, and completely annihilating a branch of agriculture, to supply its place with a manufacture less expensive of labor, and hence in the end more beneficial to man."

The Pardee School of Mines.*—The new building, at Lafayette College, erected for the Scientific Department, now occupied by the classes, was dedicated by appropriate exercises, on Tuesday, October 21st. This magnificent structure cost over two hundred and fifty thousand dollars, and is the princely gift of Mr. Ario Pardee, the founder of the Scientific Department of the College. It consists of one centre building five stories in height, fifty-three feet front and eighty-six deep, and two lateral wings one on each side of the centre building, measuring sixty-one feet in length and thirty-one in width; four stories in height, including a mansard roof, the whole terminating in two cross wings forty-feet front and eighty-four feet deep, and four stories in height. The entire length of front, in a straight line, is two hundred and fifty-six feet. The material is the Trenton brown stone, with trimmings of light Ohio sandstone. It is heated throughout by steam and lighted by gas. The first floor is mainly devoted to the study of mining and metallurgy; the second contains the geological and mineralogical cabinets, a spacious auditorium, and smaller lecture rooms, reading rooms and professors' studies. The third floor

* U. S. Railroad and Mining Register.

is devoted to the engineers. The right wing is occupied by the mining engineers. A large drawing room occupies the lateral wing, while the cross wing embraces rooms for models and various professional purposes. The left wing is occupied by the civil engineers. The lateral wing comprises a drawing-room, and the cross wing is divided into rooms for lectures, working models, collections, and the like. On the fourth floor the same ample provision has been made for the chemists. The centre building is divided into two large rooms, one for technical collections and the other an assistant's room. The lateral wings are intended for quantitative and qualitative analysis. The cross wings at the extremity of the building are occupied by additional laboratories, lecture rooms and professors' studies. The fifth floor of the centre building is mainly occupied by laboratories for original researches. In determining what rooms were needed and the best arrangement of them, similar buildings in Europe as well as in this country were carefully studied, and liberal provision has been made in all the departments of instruction for every aid which has been devised for the most thorough and attractive teaching, and also for the prosecution of original researches.

The formal dedication of such a noble building, equalled but by few college edifices in the country, was an event of the greatest interest not only to the Alumni and friends of the College, but to all who are interested in educational matters, and of still more moment to capitalists who have invested or intend to invest their money in mines, furnaces, rolling mills, chemical works, machine shops, iron shipyards, or other fields of productive activity dependent for success on the best training of minds in technical science.

Editorial Correspondence.

To the Editor of Journal of the Franklin Institute:

Dear Sir,—In the September number of the "Journal" (p. 168) is illustrated an improvement in steam-engine governors. Looking over the list of American patents for 1872, I find this improvement the subject of one which was issued on the 19th of November of that year. There is no doubt that the patentee believed his invention to be new; and the reasoning which led to it original.

More than seven years earlier, however, another person followed the same course of reasoning to the same result, and embodied his ideas in an invention for which a patent was granted him March 14th, 1865, and which could scarcely be better described in one sentence than be the claim appended to the patent of November 19th, 1872; and a number of governors constructed by him have demonstrated the success of his invention.

That two persons separated by time or space, or both, should separately arrive at the same mechanical device, is not strange; and that the later of the two should, of his own knowledge, be aware of all previous similar inventions, could not possibly be expected.

The Patent Office, therefore, undertakes, for the sum of fifteen dollars, to inform him whether his feet have pressed virgin soil, or only trodden paths known before. And one would think that when the evidence lay within its own records of less than eight years past, fifteen dollars should amply pay for a sufficient examination, and reliable information; if not, the fee ought to be increased, or graduated according to the antiquity of the subject. A. B. C.

Philadelphia, Oct. 8, 1873.

Bibliographical Notices.

Elements of Physical Manipulation. By EDWARD C. PICKERING, Professor of Physics in the Massachusetts Institute of Technology. New York: Hurd & Houghton.

The object which this work seeks to accomplish is to place within the reach of students in the physical laboratories, which have now become an established adjunct to all of our large colleges and scientific schools, a text book which shall serve them as a guide in the practice of the methods of physical investigation. In publishing this work, which is based upon the experience obtained in the Massachusetts Institute of Technology, Prof. Pickering has placed in the hands of teachers an excellent manual for instruction, and in the hands of the student a text-book the need of which has long been seriously felt. We shall, in our issues shortly following this, present to our readers specimen extracts from the work, which will be found of very general interest.

Civil and Mechanical Engineering.

THE PRINCIPLES OF SHOP MANIPULATION FOR ENGINEERING APPRENTICES.

By J. Richards, Mechanical Engineer.

[Entered according to the act of Congress, in the year 1873, by John Richards, in the office of the Librarian of Congress at Washington.]

Introduction.

In adding another to the many treatises relating to mechanics, and especially to that branch called mechanical engineering, it will be proper to explain that the purpose is to supply a want that none of the many text-books this far seem to have supplied—that of assisting the engineering apprentice in forming a true estimate of that which he has chosen as a profession, and pointing out the means of study that will lead to his understanding the principles, as well as the routine, of a shop course.

Aside from the fact that no books have been prepared with an especial view of assisting apprentices and adapted to the first stages of what we may call a mechanical education, there is the further fact that such books as are available treat of mechanical principles as consisting in mathematical formula and theoretical propositions only, overlooking the fact that such data are merely the symbols of mechanical principles, and not the principles themselves, and that a true understanding of mechanics is the result of a system of logical reasoning, which is only to be aided, and not supplanted, by rules, tables and formulæ.

A person may be a master of computations, or conversant with physics, and know little or nothing of practical mechanics, or may be a competent mechanic with but little knowledge of mathematical propositions, such as can be presented in books, and the great work of the apprentice is to connect and assimilate theoretical with applied mechanics.

It may be claimed that text-books can go no farther in treating of applied mechanics than general principles will reach—a very true proposition if the writer of mechanical books has no power of dealing with the subject farther than it is reached by theoretical deductions; but this furnishes no proof that the great share of a technical educa-

tion, which consists in what may be called special knowledge, cannot be generalized and systematized the same as that part which is now explained on general principles.

Between physics, geometry and mathematics, and their practical application to industrial processes, or, to state it more plainly, between theoretical principles and the finished product of an engineering establishment, there is a wide space, filled in with intricate processes, with which text-books deal but sparingly, and sometimes not at all. This space has to be bridged over by the apprentice as best he can, and is that part which calls for his greatest efforts.

He may, for instance, study the geometry of tooth gearing; the construction of trains of wheels and the principles that govern their action; he may learn the principles of cycloidal and epicycloidal curves, but between all this and a finished wheel are the processes of pattern-making, founding and fitting, either of which require as much or more thought and study than the geometry of gearing, which subject furnishes page after page in our text-books, yet they are almost silent on the shop processes named.

The same rule applies in most classes of machinery; in machine tools, for instance, the apprentice has only to open a modern work on the subject, and he will find tables, formulæ and drawings to show the construction of machine tools, but seldom anything said upon the principles of their operation.

The apprentice, as soon as he enters the workshop, is at once brought in contact with machine tools of all kinds, and but little is gained in spending time in studying drawings and descriptions of them when the tools themselves are before his eyes; but connected with the operation of these tools are many intricate conditions that cannot be understood nor even conjectured by merely examining the machines, and much less from drawings of them. The conditions of operation, or principles of operation, are the points that the apprentice most needs to learn; what is meant by these principles of operation will appear in the course of this work.

Referring again to the books which are available to an apprentice, they are too often filled with tables, rules, formulæ and ready-made computations, which, like a list of gear wheel combinations stamped on a lathe, tend to relieve the learner's mind of that which is most important for him to study. The apprentice who refers to a table to select wheels for screw cutting will perhaps never learn to make the combinations mentally, and by using tables and rules to

define mechanical questions, the principles may be entirely overlooked. Rules and tables have their place, and are merely a record of what has been determined and proved by crucial experiment or by mathematical demonstration, but the less the engineering apprentice deals in them the more he is likely to know of the principles upon which such rules are founded.

With books of an elementary character, until quite recently, the engineering apprentice has been no better supplied.

When it is considered how strong first impressions are and how they cling to the mind, it is easy to conceive how important it is to lay a proper foundation on which to rear a mechanical education, and when we examine school books that treat of natural philosophy and mechanics, and compare them with modern science and modern practice, it must be conceded that they furnish a bad foundation indeed for the learner to build upon.

As a first lesson in what is called mechanics, the student is taught to compute the power of levers, screws, wheels, wedges and other devices, which he is taught to call "mechanical powers," whatever that means; he is told that there are "three kinds of levers," and the terms used throughout are such as to confound power with mechanism, and prevent a comprehensive idea of force and motion, or the means of transmitting them. The student finishes such a study of mechanics with false conceptions of power and mechanism, which, as many will bear witness, clings to the mind for years, and may never cease to be a hindrance to acquiring a true appreciation of forces and the relations between power and mechanism.

A want of treatises that are especially adapted to the requirements of apprentices, is due in a great measure to the fact that practical engineers who have passed through a successful experience, and have gained that special knowledge which the apprentice most needs, as a rule have neither the inclination nor the incentive to write out the lessons that they could impart to others. The changes of mechanical manipulation are so frequent, and the apparent conflict that might arise between their opinions and established data would lead to adverse criticism, which such men do not care to invite; the result is, unfortunately, that the great mass of special knowledge gained by individual experience is lost, and mechanical text-books, of necessity, consist mainly in generalities that may be arrived at by theoretical deductions and inferences.

The purpose of these articles will be, in some degree at least, to

supply this want of a medium between theory and practice, and to point out to the apprentice engineer that part of his education which may be termed special, and must be acquired mainly by his own efforts; to urge upon him the value of analytical reasoning, about even the most simple matters, instead of depending upon rules, tables and formula.

It will also be attempted to show the relations between principles and practice, not between figures and practice; for it must continually be kept in mind that figures are but the symbols of principles, the plan of tracing every process in the workshop to some general mode of operation as an antecedent, will be urged upon the learner, as the only means of cultivating that habit of reasoning, which alone can lead to a complete knowledge of practical mechanics.

The articles will contain no drawings, no figures or computations; these are already supplied in forms that leave nothing to be desired, and may be studied from other sources in connection with what is presented here.

The author, in preparing these articles for engineering apprentices, brings to his aid an experience of twenty-five years devoted to the construction of machinery and general engineering practice; and, as a considerable part of this experience has been devoted to the instruction of apprentices in applied mechanics and what is termed mechanical engineering, the plans of study which will be pointed out here are such as this experience has proved to be the most successful.

The articles have been prepared with a full knowledge of the fact, that what an apprentice may learn, as well as the time that is consumed in learning, are both to be measured by the personal interest that is felt in the subject studied, and that a strong personal interest on the part of an apprentice is essential to permanent success as an engineer. It is to be regretted that the difficulty of a statistical dryness and want of interest must always be a characteristic of any writing devoted to mechanical subjects. Some of the subjects treated here will be open to this charge no doubt, especially in the first part; but it is trusted that the good sense of the reader will prevent him from passing hurriedly over the first part to see what is said of casting, forging and fitting, at the end, and will cause him to read it as it comes, which will in the end be best for the reader, and certainly but fair to the writer.

Plans of Studying.

By examining applied mechanics and shop manipulation, the learner

will see that the knowledge to be acquired can be divided into two departments—special and general: general knowledge, relating to tools, processes and operations, the nature and action of which may be understood from general principles, and without special or experimental instruction; the special knowledge, that which is based upon experiment, and can only be acquired by special, as distinguished from general sources.

To make this plainer it may, for example, be said that a knowledge of how to generate the teeth of wheels and their proportions, as a geometrical problem, is general knowledge that may be learned from books, and understood without the aid of an acquaintance with the technical conditions of either the mode of constructing or the manner of operating wheels; but how patterns should be made for casting wheels, or how wheels should be moulded or fitted, is special knowledge, and must have reference to particular cases.

The proportions of pulleys, bearings, screws, or other regular details of machinery, may also be learned from general rules and principles, but the hand skill that enters into their manufacture cannot be so learned.

The general design, or the disposition of metal in machine framing, can be to a great extent predicated upon rules and constants that have general application; but, as in the case of wheels, the plans of moulding such machine frames are not governed by constant rules or performed in a uniform manner; moulds may be made in various ways, and at a greater or less expense; the metal can be mixed to produce a hard or a soft casting, a strong or a weak one; the conditions under which the metal is poured may govern the soundness or shrinkage—things that are determined by special instead of general conditions.

The importance of a beginner learning to divide what he has to learn into these two departments of special and general has the double advantage of giving system to his plans and pointing out such part of his education as must be acquired in the workshop and by practical experience; the time and opportunities that might be devoted to learning the technical manipulations of a foundry would be improperly spent if devoted to metallurgic chemistry, because the latter may be studied apart from practical foundry manipulation, and without special opportunities for observation.

It may also be remarked that the special knowledge involved in applied mechanics is mainly to be gathered and retained by personal

observation and memory, and that the first lessons, learned when the mind is interested and active, should as far as possible include whatever is special; in short, no opportunity of learning special manipulation should be lost. If a wheel pattern come under notice, examine the manner in which it is framed together, the amount of draught, and how it is moulded, as well as to determine whether the teeth have true cycloidal curves.

Once, nearly all mechanical knowledge was of the class termed special, and shop manipulations were governed by empirical rules and the arbitrary opinions of the skilled; the apprentice entered the shop to learn a number of mysterious operations, which could not be defined upon principles, and only understood by special practice and experiment. The arrangements and proportions of mechanism were also determined by the opinions of the skilled, and like the manipulation of the shop, were often hid from the apprentice, and what he carried in his memory at the end of an apprenticeship was all that he had gained. The tendency of this was to elevate those who were the fortunate possessors of a strong natural capacity, and to depress the position of those less fortunate in the matter of mechanical "genius," as it was called.

The ability to prepare proper designs, and to succeed in original plans, was attributed to a kind of intuitive faculty of the mind; in short, the mechanic arts were fifty years ago surrounded by a superstition, of a different nature, but in its influences the same as superstition in other branches of knowledge.

But now all is changed; natural phenomena has been explained as being but the operation of regular laws, so has mechanical manipulation been explained as consisting in the application of general principles, not yet fully understood, but far enough so that the apprentice may with a substantial education, good reasoning powers and determined effort, force his way where once it had to be begged.

The amount of special knowledge in mechanical manipulation, that which is irregular and modified by special conditions, is continually growing less as generalization and improvements go on.

The engineering apprentice, in estimating what he will have to learn, must not lose sight of the fact that what qualifies an engineer of to-day will fall far short of the standard that another generation will fix, and of that period in which his practice will fall. This I mention because it will have much to do with the conceptions that a learner will form of what he sees around him. To anticipate im-

provement and change is not only the highest power to which a mechanical engineer can hope to attain, but is the key to success. By examining the history of great achievements in mechanical science it will be seen that their success has been mainly dependent upon predicating future wants, as well as upon the ability to supply such wants, and that the commercial value of mechanical improvements is often measured by conditions that the improvements themselves anticipate; the invention of machine-made drills, for instance, was but a small matter, but the want that has grown up since their existence has rendered this improvement one of great value; moulded bearings for shafts was also a trifling improvement when first made, but it has since influenced machine construction in America in a way that has given great value to the invention.

It is generally useless and injudicious to either expect or to search after radical changes, or sweeping improvements in machine manufacture or machine application, but it is important in learning how to construct and apply machinery that the means of foreseeing what is to come should at the same time be re-studied. The attention of the learner can be directed to the division of labor, improvements in shop system, how and where commercial interests are influenced by machinery, what countries are likely to develop manufactures, the influence of steam hammers on forging, the more extended use of steel when cheapened by improved processes for producing it, the division of mechanical industry into special branches, what kinds of machinery may become staple, such as shafting, pulleys, or wheels, and so on; these are mentioned at random to indicate what is meant by looking to the future as well as at the present.

Following this subject of future improvement farther, it may be assumed that an engineer who understands the application and operation of some special machine, the principles that govern its movements, the endurance of the wearing surfaces, the direction and measure of the strains, and who also understands the general principles of the distribution of material arrangement and proportions, that such an engineer will be able to construct a machine, the plans of which will not be materially departed from so long as the nature of the operations to which the machine is applied remains the same.

A proof of this proposition is furnished in the case of standard machine tools, a class of machinery that has received the most thorough attention at the hands of our best mechanical engineers. Standard tools for turning, drilling, planing, boring and so on, have been

changed but little during twenty years past, and bid fair to remain nearly the same in future.

A lathe or a planing machine made by a first-class establishment twenty years ago has, in many cases, the same capacity, and is worth nearly as much in value at the present time as the machines of modern construction—a test that more than any other determines their comparative efficiency and the value of improvements made.

The plans of the framing for machine tools has been altered, and many improvements in details have been added; yet, upon the whole, it is safe to assume that machine tools have reached a state of improvement that precludes any radical changes in future, so long as the operations in metal cutting remain the same.

This state of improvement, which has been reached in machine tool manufacture, is not only the result of the skill expended on such tools, but because they are the agents of their own production; machine tools produce machine tools, and a workman should certainly become skilled in the constructian of implements that he uses continually in his own business.

Noting the causes and conditions that has led to this perfection in tool manufacture, and how far they apply in the case of other classes of machinery, will indicate the probable improvements and changes that the future will produce. The functions and adaptation of machinery constitute, as already explained, the science of mechanical engineering. The functions of a machine is a foundation on which its plans are based; hence, machine functions and machine effects are matters to which the attention of an apprentice should be first directed. In the class of mechanical knowledge that has been defined as general, construction comes in the third place; first machine functions, next plans or adaptation of machines, and third the construction of machines. This should be the order of study pursued in learning mechanical manipulation. Instead of studying how drilling machines, planing machines or lathes are arranged, and next plans of constructing them, and then the principles of their operation, which is the usual course, the learner should reverse the order, studying first drilling, planing and turning as operations, next the adoption of tools for the purposes, and third plans of constructing such tools.

Applied to steam engines the same rule holds good. Steam, as a motive agent, should first be studied, then the operation of steam machinery, and finally the construction of steam engines. This is a rule that may not apply in all cases, but will serve to assist the learner in

forming plans in most cases, and adopting a regular mode of proceeding in his studies.

To follow the same chain of reasoning further, and to show what may be gained by method and system learning in mechanics, it may next be assumed that machine functions consist in the application of power, and that power should therefore be first studied; of this there can be but one opinion. The learner who sets out to learn even the elementary principles of mechanics without first having formed a true conception or an appreciation of power as an element, is in a measure, wasting his time and squandering his efforts. Any truth in mechanics, even the action of the "mechanical powers" before alluded to, is received with an air of mystery, unless the nature of power is first understood; practical demonstration a hundred times repeated does not create a conviction of truth in mechanical propositions, unless the principles of operation are understood. An apprentice may learn that power is not increased or diminished by being transmitted through a train of wheels that change both speed and force, and he may believe the proposition without having a "conviction" of its truth. He must first learn to regard power as a constant and indestructible element, something which can be weighed, measured and transmitted, but not created or destroyed by mechanism—then the nature of the mechanism may be understood, but not before.

To obtain a true understanding of the nature of power is by no means the difficulty, for a beginner, that is generally supposed, and when once reached, the truth will break upon the mind like a sudden discovery and ever afterwards be associated with mechanism and motion whenever seen. The learner will afterwards find himself analyzing the flow of water, the traffic in the streets, the movement of ships and trains; or even the act of walking will become a manifestation of power, all clear and intelligible, without that air of mystery that is otherwise inseparable from the phenomena of motion.

If the learner will go on farther, and study the connection between heat and force, the mechanical equivalent of heat when developed into force and motion, and the re-conversion of power into heat, he will have commenced at the base of what must constitute a thorough knowledge of mechanics.

I am well aware of the popular opinion that such subjects are too abstruse to be understood by beginners—an assumption that is founded mainly in the fact that the subject of heat and motion are not generally studied and have been too recently demonstrated in a

scientific way to command confidence and attention; but the subject is really no more difficult to understand in an elementary sense than that of the relation between movement and force illustrated in the "mechanical powers" of school books, which no apprentice ever did or ever will understand, except by first studying the principles of force and motion independent of mechanical agents.

It is to be regretted that there has not been books especially prepared to instruct mechanical students in the relations between heat, force, motion and mechanism. The subject is, of course, treated at great length in modern scientific works, but is not connected with the operations of machinery in a way to be understood by beginners.

A treatise on the subject, called "The Corelation and Conservation of Forces," published by D. Appleton, of New York, is perhaps as good a book on the subject as can at this time be referred to. The work contains papers contributed by Professors Grove, Helmotz, Faraday and others, and has the advantage of arrangement in short sections, that compass the subject without making it tedious.

In respect to books and reading, the apprentice should supply himself with references; a single book and the best one that can be obtained on each of the different branches of engineering is enough to begin with.

A pocket-book for reference, such as Molesworth's or Nystroms', is of use and should always be at hand.

For general reading, nothing compares with the scientific and technical journals, which are now so replete with all kinds of information that, beside noting the present progress of engineering industry in all parts of the world, they contain nearly all besides that the learner will require.

It will be found that information of improvements and mechanical progress that the learner may gather from serial publications can always be exchanged for special knowledge in his intercourse with skilled men, and what the apprentice may read in an hour can often be "exchanged" for experimental knowledge that has cost years to acquire.

Finally, I will say to the learner set out "*de novo*" in your plans, with a determination to succeed, and if your judgment commends it, with originality, only have system and method from the first, avoiding however, any course that will provoke rivalry or resentment on the part of others around you.

Mechanical Engineering.

These articles, as already explained, are to be devoted to mechan-

ical engineering, and in view of the difference of opinion that exists as to what mechanical engineering comprehends, and the different sense in which the term is applied, it will be proper to explain what is meant by it here.

I am not aware that any one has defined what constitutes civil engineering, or mechanical engineering, as distinguished one from the other, nor is it assumed to fix any standard here farther than to serve the purpose of defining the sense in which the term will be used; yet there seems to be a clear line of distinction which, if it does not agree with popular use of the terms, at least seems to be furnished by the nature of the business itself. It will therefore be assumed that mechanical engineering relates to works that *involve machine motion*, and comprehends the conditions of machine action, such as centrifugal strain, intermittent and irregular strains in machinery, the endurance of wearing surfaces, the constructive processes of machine making and machine effect in the conversion of material—in short, agents for transmitting and applying power.

Civil engineering will be assumed to works that do not *involve machine motion*, nor the use of power, and deals with the strength, nature and disposition of material under constant strains, or under measured strains, the durability and resistance of material, the construction of bridges, factories, roads, docks, canals, dams, and so on; also, leveling and surveying.

This corresponds to the most common use of the term civil engineering in America, but differs greatly from its application in Europe, where civil engineering is understood as including machine construction, and where the term engineering is applied to ordinary manufacturing processes for the production of staple articles.

Civil engineering, in the meaning assumed for the term, has become almost a pure mathematical science, constants are proved and established for nearly every computation, the strength and durability of materials, from long and repeated tests, has come to be well understood, and, as in the case of machine tools, the uniformity of practice among civil engineers and the perfection of their works, attest how far civil engineering has become a true science, and argues that the principles involved are well understood.

To prove how much is yet to be learned in mechanical engineering, we have only to apply the same test, and when we contrast the great variance between the designs for machines and the diversity of their operation, even when applied to similar purposes, their imperfection

is at once apparent. Even if the rules of construction were uniform and the principles of machine operation as well understood as the strength and arrangement of material in permanent structures, still there would remain the great difficulty of adaptation to new processes that are continually being developed—if the steam engine, for instance, had forty years ago been brought to such a state of improvement as to be constructed with standard proportions and arrangement for stationary purposes, all the rules, constants and data of whatever kind that had been collected and proved, would have been but of little use in adapting the steam engine to railways and navigation in the present day. I revert to this change in machine adaptation that is constantly going on to warn the apprentice of the task he will find before him. Mechanical engineering has by the force of circumstances been divided up into classes, such as engineering tools, railway machinery, marine engineering, and so on, either branch of which constitutes a profession within itself, and the most thorough study will be needed to master general principles, and then a further effort to acquire proficiency in some special branch, without which there is but little chance of success at the present day. But few men, even under the most favorable conditions, have been able to qualify themselves as competent mechanical engineers sooner than at forty years of age.

To master the various details of machine manufacture, including draughting, founding, forging and fitting, is of itself a work equal to most professional pursuits, to say nothing of manual skill, and when we come to add machine functions and their application, generating and transmitting power, with other things that will necessarily be included in practice, the task assumes proportions that makes it appear a hopeless one; besides, the work of keeping progress with the mechanic arts calls for a continual accretion of knowledge, and it is no small labor to keep informed of the continual changes and improvements that are going on in all parts of the world, which may at any time modify and change both machines and processes.

One of the earliest cares of an apprentice should be to divest his mind of what I will call the romance of mechanical engineering that is almost inseparable from the views acquired in technological schools. He must remember that it is not a science he is studying, and that mathematics deal only with one branch of what is to be learned: special knowledge, or what does not come within the scope of general principles, must be gained in a most practical way at the expense of hard work, bruised fingers, and a disregard of much of what the world calls gentility.

Looking ahead into the future, he can see a field for the mechanical engineer widening on every side; as the construction of permanent works becomes more settled and uniform, the application of power becomes more diversified, and develops questions of greater intricacy. No sooner has some great improvement, like railway and steam navigation, settled into a system of regularity than new enterprises begin.

To offset the undertaking of so great a work as the study of mechanical engineering, there is the very important advantage of the exclusiveness of the calling—a condition that arises out of its difficulties. If there is a great deal to learn, there is also much to be gained in learning it. It is seldom, indeed, that an efficient mechanical engineer fails to command a place of trust and honor, or to accumulate a competence by means of his calling.

If a civil engineer is needed to survey railways, construct docks or bridges, buildings or permanent plant of any kind, there are scores of men ready for the place, and qualified to discharge the duties; but if an engineer is wanted to design and construct machinery, he is not so easy to be found, and if found there remains that important question of competency; for the work is not like that of constructing permanent works, where several men may and will perform the undertaking very much in the same manner and perhaps equally well. With machinery its success will be directly as the capacity of the engineer, who has but few precedents and still fewer principles to guide him, and generally has to set out by relying mainly upon his special knowledge of the operation and application of the machines that he is to construct.

Engineering as a Calling.

It may in the abstract be claimed that the dignity of any pursuit is or should be as the amount of good it confers, and the influence it exerts for the improvement of mankind.

The social rank of those engaged in the various avocations of life has, in different countries and in different ages, been defined by various standards. Physical strength and courage, hereditary privilege, and other things that once recommended men for preferment, have now lost their importance or passed away entirely, and nearly the whole civilized world have agreed upon one common standard, that knowledge and its proper use shall be the highest and most honorable attainment to which people may aspire.

It may be useless or even wrong to institute invidious comparisons batween different callings which are all useful and necessary, and the matter is not introduced here with any view of exalting the engineering profession; it is even regretted that the subject is to be alluded to at all, but there is too much to be gained by the apprentice having a pride and love for his calling to pass over the matter of its dignity without calling attention to it.

Besides, the gauntlet has been thrown down and comparison provoked by the unfair and unreasonable place that the politician, the metaphysician and the moral philosopher have in the past assigned to the constructive arts. Poetry, metaphysics, mythology, war and superstition have, in their time, engrossed the literature of the world, and formed the subject of what alone was considered education. In a half century past all has changed; the application of the sciences in manufacturing, the transportation of material, the preparation and diffusion of printed matter, the utilization of natural forces, and other great matters of human interest, has come to shape our laws, control commerce, establish new relations between people and countries, in short has revolutionized the world. So rapid has been this change that it has outran the powers of conception, and people wake up as from a dream to find themselves governed by a new master.

Railways have done more to develope civilization than all the influence exerted since the world began by what was, a century ago, called "learning."

Considering scientific progress as consisting primarily in the demonstration of truths, and, secondly, in their application to useful purposes, we can see the position of the engineer as an agent in this great work of reconstruction that is now going on around us; it is certainly a proud one, but not to be attained except at the expense of great effort and a denial of everything that may interfere with the acquirement of knowledge during apprenticeship and the study that must follow.

The mechanical engineer deals mainly with the natural forces and their application to the conversion of material, and transport; his calling involves arduous duties; he is brought in contact with what is rough and repulsive, as well as what is scientific and refined. He must include grease, dirt, manual labor, undesirable associations and danger in apprenticeship, or else be content to remain without thoroughly understanding his profession.

The Conditions of Apprenticeship.

Were it not that moral influences in learning mechanics, as in all other kinds of education, lie at the bottom of the whole matter, the subject of this article would not have been introduced; but it is the purpose, so far as possible, to notice everything that concerns an apprentice and learner, and especially what he has to deal with at the outset.

To acquire information or knowledge of any kind successfully and permanently, it must be a work of free volition as well as from a sense of duty or expediency, and whatever tends to create love and respect for a pursuit or calling, becomes the strongest means for its acquirement.

The interest taken by an apprentice in his business is for this reason greatly influenced by the opinions that he may hold concerning the nature of his engagement.

The subject seems in the abstract to be one of commercial equity, partaking of the nature of ordinary contracts, and no doubt can be so construed so far as an exchange of "considerations," but no farther. Its intricacy is establishad by the fact that all countries where skilled labor exists have attempted legislation to regulate apprenticeship and define the relations between the master and apprentice; but, aside from preventing the abuse of power that has been delegated to masters, and in some cases forcing a nominal fulfilment of engagements, such legislation, like that intended to control commerce and trade, or the opinions of men, has failed to attain the objects for which it was intended.

This failure of laws to regulate apprenticeship, which existing facts fully warrant us in assuming, is due in a large degree to the impossibility of applying general rules to special conditions; it may be attributed to the same causes that makes it useless to fix values or the conditions of exchange by legislation.

What is needed is that the master, the apprentice and the public should understand the true relations between them, the value of what is given and what is received on both sides. When this is understood the whole matter will regulate itself without any interference on the part of the law.

The subject is an intricate one, and is, moreover, so changed by the influence of science and machinery, and a corresponding decrease in what may be called special knowledge, that rules and propositions that would fifty years ago apply to the conditions of apprenticeship,

will at the present day be wrong and unjust; besides, the distinction between hand skill and mental skill, as I will term them, the exclusiveness or general character of the business, the irregularity of value, both of what is learned and the labor given in return, with other conditions not easy to determine even in a special case, makes the subject of apprenticeship a most difficult one to consider.

Viewed in the commercial sense, as an exchange of considerations or values, apprenticeship can be regarded like other engagements; but, as intimated before, the analogy ends here. What the apprentice gives as well ns what he receives are alike too conditional and indefinite to be estimated by ordinary standards.

The apprentice exchanges unskilled or inferior labor for technical knowledge, or for the privilege of the means for its acquirement.

The master is presumed to impart special knowledge, that has been collected at great expense and pains, as a premium for the assistance derived from the unskilled labor of the learner. This special knowledge may be imparted in a longer or shorter time; it may be thorough and valuable, or not thorough and almost useless.

The privileges of a shop may be such as to offset a large amount of labor on the part of the apprentice, or this privilege may be of such a character as to inculcate erroneous ideas, and teach inferior plans of performing work.

On the other hand, the amount that an apprentice may earn by his labor is governed by his natural capacity, and by the interest he may feel in advancing, also from the view he may take of the equity of his engagement, and whether he is able to place a proper estimate upon the privileges he may enjoy and the instruction received.

In many branches of business, where the nature of the operations carried on are measurably uniform, and have not for a long time been much affected by changes and improvements, the conditions of apprenticeship are more easy to define; but mechanical engineering is the reverse of this, it lacks uniformity both as to practice and what is produced, and is rapidly and continually changing.

As a rule, apprentices overrate their services, especially at the beginning, and set a value on what they perform far in excess of the true one.

To estimate the actual value of labor in an engineering works is not only a very difficult matter, but to some extent impracticable even by those of long experience and skilled in such computations; and it is not to be expected that a beginner will be able to understand the

conditions that govern the value of his labor, and he is generally led to the conclusion that he is unfairly treated, that his services are not sufficiently paid for, and that he is not advanced rapidly enough.

With these conclusions in his mind no great progress will be made, and hence the introduction of the subject here. There is no hope of explaining the position of an engineering apprentice satisfactorily to those who have not passed through a course themselves, and acquired experience as a learner, workman, manager and master. It is impossible to form correct opinions of matters that we do not understand, and besides what may be pointed out here there will remain many points which the apprentice must accept upon the grounds of precedent and custom.

Technical knowledge and skill are considerations that may be bought or sold, but cannot be transferred from one person to another —has a commercial value, but cannot be gained as an education for commercial considerations, but must be paid for in a long term of labor, partially remunerated, both during apprenticeship and for a time in after-practice.

The commercial value of professional or technical knowledge is generally as the amount of time, effort and unpaid labor that has been devoted to its acquirement.

This value of technical knowledge is sometimes modified by the exclusiveness of some branch that has been made the object of special study. This exclusiveness is, however, becoming exceptional, as the secrets of manufacture and special knowledge are supplanted by the application of general principles, and should at this day not be estimated as a condition of importance; it is a kind of artificial protection thrown around certain branches of industry, that must soon disappear, as unjust to the public and unnecessary to success.

In business arrangements, technical knowledge and professional experience become capital, and offset money or other assets of a business; not under any general rule, nor even as a consideration which the law can define the value of, or prescribe conditions for, and for the same reasons that the law cannot prescribe conditions upon which such knowledge may be acquired.

This view of technical knowledge in relation to money in the organization of business firms, and wherever it becomes necessary to give it a commercial value, is the best and almost the only source from which the apprentice can form a true idea of the value of what he is to acquire during his apprenticeship.

When an apprentice enters the works to begin his trade, he at first forms an exaggerated estimate of what he has to learn; it presents to his mind not only a great undertaking, but a kind of mystery, which he fears that he may not be able to master. The next stage is when he has made some progress, and begins to underrate the task before him as it was at first overrated. In this reaction he imagines that the main trouble is past, that he has already mastered all the leading principles of mechanics, which is after all but a "small matter." In a third stage, the apprentice experiences a return of his first impressions as to the difficulty of his undertaking; he begins to see his calling as one that must involve endless detail, comprehending things which can only be studied in connection with personal experience; he sees "the horizon widen as it recedes," that he has hardly begun the task instead of having it completed, and almost despairs of its final accomplishment.

This last impression will last through life; practice will cause him to fix continually a higher estimate upon technical knowledge, until at the end of a long experience he will come to the conclusion that apprentices are the happy recipients of a bounty for which no adequate return is given.

Without assuming that this last estimate of mechanical knowledge is the true one, the apprentice is cautioned against underestimating such knowledge; it is the most intricate thing that he will have to deal with, not only during the course of apprenticeship but in various questions that are sure to arise in practice afterwards.

An engineer is expected to be, and should be, qualified to value and determine considerations in partnership and business, where this element of special knowledge and skill will often have to be estimated and balanced by money, time or other considerations.

In the workshop, mechanical knowledge of some kind is continually and often insensibly acquired by a learner, who cannot help observing the operations that are going on around him; he is continually availing himself of the experience of those more advanced, and learns by association the rules and customs of the shop, of the business, and of discipline and management. He gathers the technical terms of the fitting shop, the forge and foundry, notes the operations of planing, turning, drilling and boring, with the names and application of the machines directed to those operations. He sees the various plans of lifting and moving material, the arrangement and relation of the several departments to facilitate the course of the work in process.

He also learns where the product of the works is sold, discusses the merits and adaptation of what is constructed, which leads to considering the wants that create a demand for this product, and the extent and nature of the market in which it is sold.

All these things are technical knowledge, and the privilege of their acquirement an element of value. The common view taken of the matter, however, is that it costs nothing to a master to afford these privileges, the work must at any rate be carried on, and is not retarded by being watched and learned by apprentices. This is wrong; the very existence of a business may depend upon the profits from labor received in exchange for the privileges of apprentices, the operations of an engineering establishment are not to be confounded with those of regular manufactories; the first involves continual risk, and depends constantly upon the exercise of engineering skill, the latter is merely the conversion of material by processes that are constantly the same, and in which the engineering element has been furnished by those who constructed the machinery and made plans for the processes.

Viewed from any point, the privileges of engineering establishments have to be considered as an element of value, to be bought at a price, just as a ton of iron or a certain amount of labor in a commercial sense, as the equivalent of labor, material or money.

The value of such privileges is, however, comparative, and varies as the nature of the business carried on, and the manner in which the work is done, a matter that will be again alluded to in another place.

To turn now to the other side, without at this time noticing farther what an engineering apprentice receives, we will consider what is given in return—what accrues to the master from apprentice engagements.

Leaving out the question of premiums, we find on this side a single consideration, a certain amount of unskilled service performed by the apprentice.

This service is presumed to be given at a reduced rate, or sometimes without compensation, in return for the privileges of the works and the instruction that is received; but the value of this service is so hedged about with intricacies that it is almost as hard to determine the value of, as the considerations that it is rendered for.

The apprentice sees what his hands have performed, compares it with what a skilled man will do, and estimates it accordingly, assuming that his earnings are in proportion to what is performed; but this is a mistake, and a very different standard must be assumed to arrive at the true value of such labor.

Apprentice labor, as distinguished from skilled labor, has to be charged with the extra attention in management, the loss by a forced classification of the work, the influence in lowering the quality of the work and the amount performed by skilled men, the risk of detention by failure or the loss of material, and the imperfect character of the work performed. The apprentice must also be charged with the same, if not a greater expense than the skilled workman for light, room, oil, tools and office service.

Attempts have been made in the best-regulated engineering establishments to ascertain the value of apprentice labor, but, so far as I know, without satisfactory results in any case.

If not combined with skilled labor, it would be comparatively easy to determine the value of apprentice labor, but when it comes up as an item in the aggregate of labor charged to a machine or some special work constructed it is difficult to even approximate its worth.

Leaving premiums out of the question, and referring to such first-class establishments that do not demand them, or to cases in which premiums are not paid, there is no doubt of the common estimate placed by masters upon apprentice labor being in excess of, rather than below the true value.

A condition of apprenticeship, that is equally difficult to define with the commercial value of mechanical knowledge, or that of apprentice labor, is the extent and nature of the facilities that different establishments offer to the learner. In speaking of the mechanical knowledge, and the privileges of learners, and engineering works in a general way, it must, of course, be assumed that such works afford full facilities for learning some branch of work, by the best practice, and in the most thorough manner; but, in fact, such establishments are graded from the highest class on the best branches of work, where a premium would be equitable, down to the lowest class performing inferior branches of work, where there can be little if any advantage gained by serving an apprenticeship on any terms.

Besides this want, or difference of facilities that engineering establishments afford, there is the farther distinction to be made between an engineering establishment and one that is directed to the manufacture of staple articles.

This distinction between engineering and manufacturing is quite plain to engineers themselves, but in many cases is not so to those who are to enter as apprentices, nor to friends who advise them; and in every case where engagements are made there should be the

fullest possible investigation as to character of the works where the engagement is intended; not only to protect the learner, but to protect regular engineering establishments in the advantages to be gained by apprentice labor. A machinist or a manufacturer who uses the muscular strength and the ordinary faculties only of men in his operations, can afford to and should pay an apprentice from the beginning a fair share of his earnings; but an engineering works that projects plans, generates designs and assumes risks based upon skill, and special knowledge is very differently situated in regard to apprentice labor.

The difference between engineering and manufacturing may be best explained by saying that to manufacture is to carry on processes for converting material; such processes being constantly the same, or approximately so, and such as do not call for the continual exercise of mechanical knowledge in the workmen.

The intricacies arising from the division of these branches of engineering, machine fitting and manufacturing, together with the indiscriminate application of the term "engineering" to even the coarsest branches of manufacturing in England, has led to very confused ideas upon the subject, and I offer the following propositions and suggestions that will be of use in selecting a place and in making terms for an apprentice course.

1st. The facilities afforded for engineering apprentices in any establishment is as the amount of skill and knowledge employed in its operations, the originality of the plans, the order and system with which the works are conducted and the character of the fitting performed.

2d. The extent of an establishment is never a measure of its claims as a place of learning for apprentices, except it has been built up by superior engineering skill instead of commercial sagacity or a train of favorable circumstances. The larger the works the greater the division of labor; and assuming an establishment to represent a given amount of engineering skill, the smaller the establishment the better it is as a place of training.

3d. The public reputation of what is called engineering firms is as likely to be based upon commercial success as upon their professional ability, and is not always to be taken as a measure of the facilities they afford for apprentices, and as applications from those who do not understand the nature of engineering establishments are most likely to be made to popular firms, the inferences are that smaller

firms will not only make better terms, but afford better facilities for the learner.

The name of having been an apprentice to a famous firm may sometimes have an influence in enabling an engineer to form advantageous commercial connections, but will in the end be of but little use; such an apprenticeship is of value only as it has furnished substantial knowledge and skill, for every one will, sooner or later, come down to the solid basis of his actual abilities and acquirements. The engineering interest is by far too intelligent to recognize the shadow instead of the substance, and there is but little chance of deception in a calling that deals mainly with facts, figures and demonstrative skill.

The value of the facilities offered to the learner in different works, as I have attempted to show, vary in each case, and while there has been an effort to establish general rules and terms upon which apprentices should be engaged, such rules are of no use, and, if generally applied, would be unjust, either to the master or apprentice, in many cases. Each establishment should establish its own rules, and should also discriminate between different apprentices in the matter of their advancement. Whenever an engagement is to be made, it should be conditional as far as possible, leaving the position and progress of the learner contingent upon his exertions and the value of his services.

It is never safe to enter an establishment without first ascertaining its character from disinterested persons, who are qualified to judge of the facilities it affords. As a rule, every machine shop proprietor imagines his establshmant to combine all the elements of an engineering business, and the fewer the facilities for learners, usually the more extravagant this estimate; so that opinions in the matter, to be relied upon, should come from extraneous sources.

In regard to premiums, it is a question to be determined entirely by the nature of the facilities that are allowed to the apprentice, assuming, of course, that the works can afford facilities, the value of which will exceed that of the services rendered by the apprentice. To include experience in all the departments of an engineering establishment, within a reasonable term, none but those of unusual ability can make their services of sufficient value to offset what they receive, and there is no doubt but that premium engagements, when the amount paid is based upon the actual conditions of the case, are fair and equitable. There is, however, this to be remembered, that the considerations that more especially balance the

premium, such as a term at draughting, designing and office service, can be mainly acquired by self-effort; while the practical knowledge of moulding, forging and fitting cannot; and an apprentice, who has good natural capacity, may, by the aid of books and such opportunities as shop experience affords, qualify himself very well without including the premium departments in his course.

Finally, it must constantly be borne in mind that what will be learned is no less a question of facilities than effort, and that the means of study are closed to none who, at the beginning, form proper plans and follow them persistently.

(To be continued.)

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 236.)

"Belting, gearing and unbalanced pulleys or wheels represent transverse strain, which must be a matter of judgment rather than estimates. It would be folly to predicate the transverse strain upon a shaft as being simply the tension of belts, or the strain of gear wheels working under ordinary conditions. A rule in the author's practice has been in the case of belts to provide sufficient strength in shafts and supports to tear them asunder, without damage to the machinery. This is the only safe rule, for there is no means of always guarding against winding belts.

"Calling the distance between the hangers or bearings b, the diameter of the shaft d, and width of belt w, a rule for ordinary cases would be $w = d^2$ and $d \times 25 = b$. This is, of course, arbitrary; and presuming the pulleys to be in the centre between the bearings, and not more than five faces in diameter. In proportioning shafts for belting, much must be left to judgment, and be dictated by that peculiar sense of realizing what is wanted from previous experience.

"There are, in fact, so many obscure conditions that have to do with the matter, that any rule must be an arbitrary one, if given for general application. The above is, however, safe, so far as strength is concerned, for gearing, shafts must, as a rule, be stronger than for belts. The motion is positive, and lacks the elasticity that exists in belt connections. Shafts are in general made strong enough to crush cast-iron gearing; practice has given larger proportions to shafts that receive gearing, no doubt for the reasons stated, that of positive motion; yet the proper plan in the construction of wood machines would

in all cases be to drive the first movers with belting so proportioned and arranged that it would be sure to yield before breaking the gearing. Ordinary belting, with its surfaces dry, as they must be when operated on wood-working machines, has much less driving power than the belting on metal-working machines, when the surfaces become covered with oil or gum, and the leather soft and pliable. Assuming the belts to be dry, a good rule for belting and gearing for feeding wood machines would be as follows: Let V be the velocity of the belt, and v that of the pinion or first mover, the width of the belt to be the same as that of the gearing $\frac{V}{6} = v$; or, in other words, the diameters of the pulleys to be to the pinion as 6 to 1, with equal faces: variations as to relative width should be directly as the proportion between pinion and pulley; if, for instance, the face of the pinion was reduced to 2 inches, and the belt remain 3 inches wide, their velocities would require to be $v \times 4 = V$, or diameter as 1 to 4, the diameter of the shaft being equal to the square root of the face of the pulley. There would with these proportions be no danger of breaking either shafts or gearing, it being understood, of course, that in a train of gearing such as is used in planing machines, the force and pitch of each wheel and shaft should be inversely as their velocity.

"The belting for circular saws is, as a rule, too narrow, or upon pulleys of too small diameter. To drive a saw well and without injurious strain upon the bearings, belts should be one-third the diameter of the saw in width, and the pulley equal in diameter to the width of the belt, which is a very simple rule, and does not give any more than the needed driving force, under fair conditions.

"One-fourth the diameter of the saw for the diameter of pulleys on cross cutting spindles. Their faces can be one and a half diameter in length.

"That speed should be an element in estimating belt contact is apparent in looking at the spindle pulleys in wood-cutting machines. The degree in which belts are affected by centrifugal force in running at high speed is dependent upon the tension, weight and flexibility of the belt and the diameter of the pulley. At 5000 feet a minute, with belts of ordinary harness leather, running on pulleys six inches or less diameter, the amount of contact is not more than three-fifths of what would be shown in a diagram, and is often much less.. Coupled with this, however, is the strange fact that the tractive force does not

seem to be as constant as the amount of contact. That the pressure on so much of the surface as has contact is increased by the belt 'lifting,' is unquestionably the case, but it hardly accounts for the want of proportion between the power transmitted and the amount of contact. This matter is mentioned as an experimental fact, and merely to stand as a reason for saying that the width of the belts need not be predicated directly upon the pulley contact for high speed spindles.

"For spindles having unusually high speeds, the writer has found belts of cotton webbing to be preferable. Such belts, if closely woven and of the best material, will, when waxed, be found to have a high tractile power and wear well, while their comparatively light weight avoids their lifting from centrifugal force.

"The convexity of pulleys to keep belts central should be sufficient for the purpose, and no more. It is difficult to account for the practice of many builders of wood machines, especially in England, who give a degree of convexity to pulleys that interferes with the contact and tends to the destruction of the belt, unless both pulleys have their faces the same, a thing impossible in the case of shifting belts. Without entering into an examination of the laws and conditions that govern the matter, the following rule is given:

"For pulleys from two to twenty-four inches face, the convexity should be from one-eighth of an inch to one-sixteenth of an inch to a foot, graduated inversely as the width of the faces; for pulleys of narrower face, the convexity can be slightly increased.

"This is quite sufficient to govern the running of belts, and a necessity for more can safely be construed as a fault in the position of the shafting.—*J. Richard's Treatise on Wood Machinery. E. & F. N. Spon, London.*

"*Loose pulleys.*—I have had great trouble in procuring a small loose pulley that would stand running at a high rate of speed with a very tight belt. After trying a large number of different kinds, of wood and iron, with long and short bearings, bushings of Babbitt, copper, etc., none of which would stand more than two months, I at last procured some sole leather; I put the flat surfaces together and bolted through with four bolts; after boring and turning I soaked it well in oil and put in place. It has now been running about one year, and is, apparently, as good as new. It requires very little oil."—*G. P., in Scientific American*, September 20, 1873.

(To be continued.)

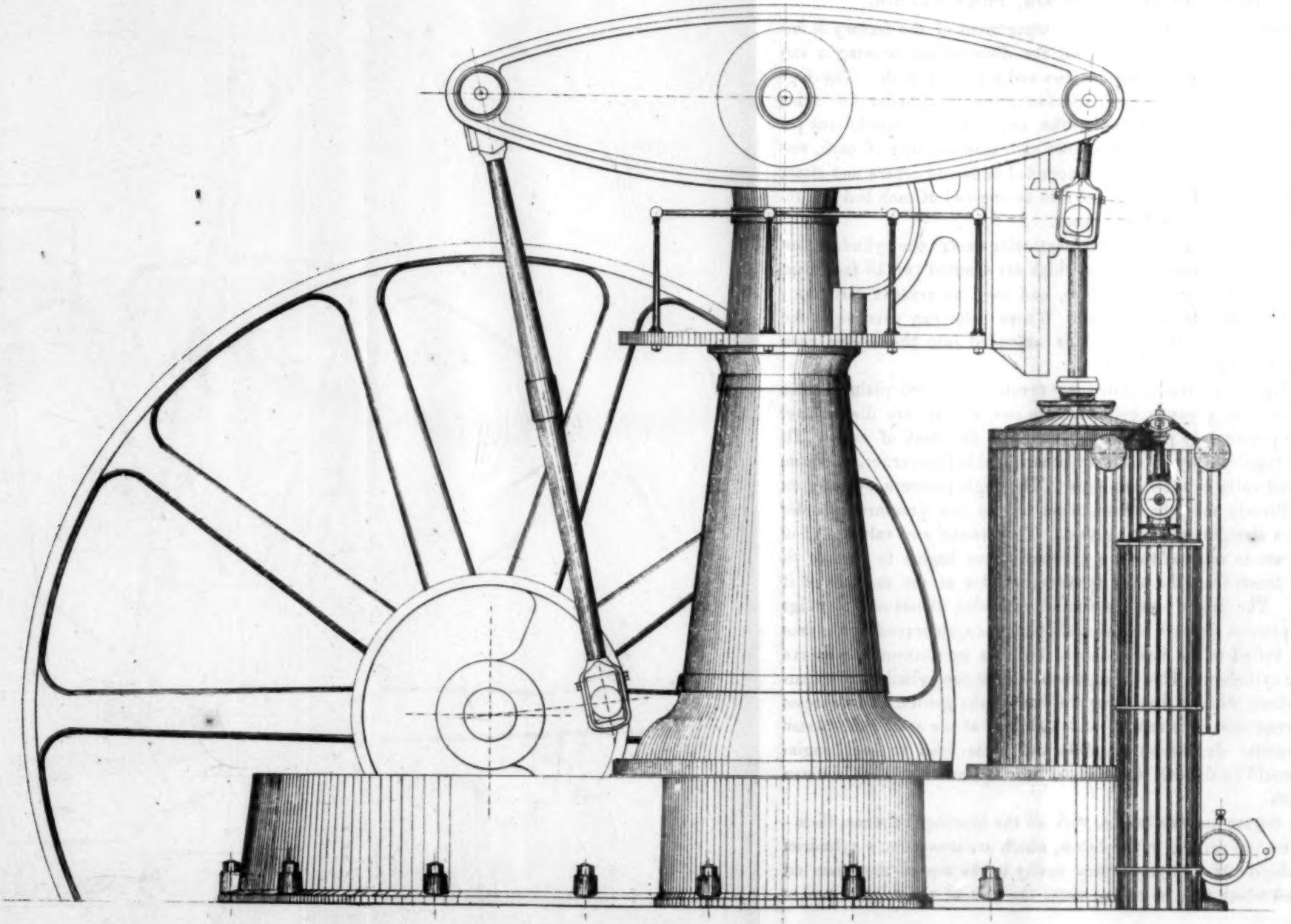
COMPOUND BEAM ENGINE AT THE WOOLEN MILLS OF MESSRS. JOHN AND JAMES DOBSON, PHILADELPHIA.

The motive power of the carpet department of the factory is furnished by a compound beam engine, the illustrations showing a side elevation of the high pressure engine and a plan of both. The high pressure cylinder is 26 inches, the low pressure cylinder 50 inches diameter; both have four feet stroke, and make fifty revolutions per minute. The cylinder, beam column and shaft-bearing of each, rest upon deep box bed plates, having rounded ends and centre and closed top. The rock shaft-bearings are cast to one end of each bed and the crank wheel pit formed in the other.

The engines are alike in every particular except the cylinders, and are connected to one shaft, upon which are secured two 16 feet diameter fly-wheel pulleys, 37 inch face, and each at present carrying a 30 inch wide double leather belt. These belts run over eight feet pulleys on the line shaft which is extended into the engine room from the factory.

The high pressure cylinder is provided with two plain D slide valves, the low pressure cylinder with one, and all are disburdened of steam pressure by packed rings—one on the back of each. The speed is regulated by an ordinary centrifugal ball governor, operating a balanced valve in the steam-pipe. The high pressure cylinder exhausts directly into the steam-chest of the low pressure cylinder, through a straight connecting pipe. The cranks and valves of both engines are so set that the low pressure piston begins to receive the exhaust steam from the high pressure cylinder at the moment of its release. The crank pins are carried by loaded wheels counterweighing the pistons. In each engine a slipper guide, embraced by the cross head, is bolted to the beam column, but has no connection whatever with the cylinders. This arrangement allows the cylinders to expand and contract without displacing the line of the guides, and possesses all the requisites of strength and stability, at the same time permitting a similar disposition of guide and cross head to each engine, which would be difficult to produce over cylinders of such different diameters.

Each engine has two beams, with all the bearings between them—the centre pin resting in two boxes, which are secured in a cylindrical block adapted to a corresponding cavity in the top of the beam column, and which may be turned about the axis of the column, and se-



COMPOUND BEAM ENGINE—Built at People's Works, Philad'a.

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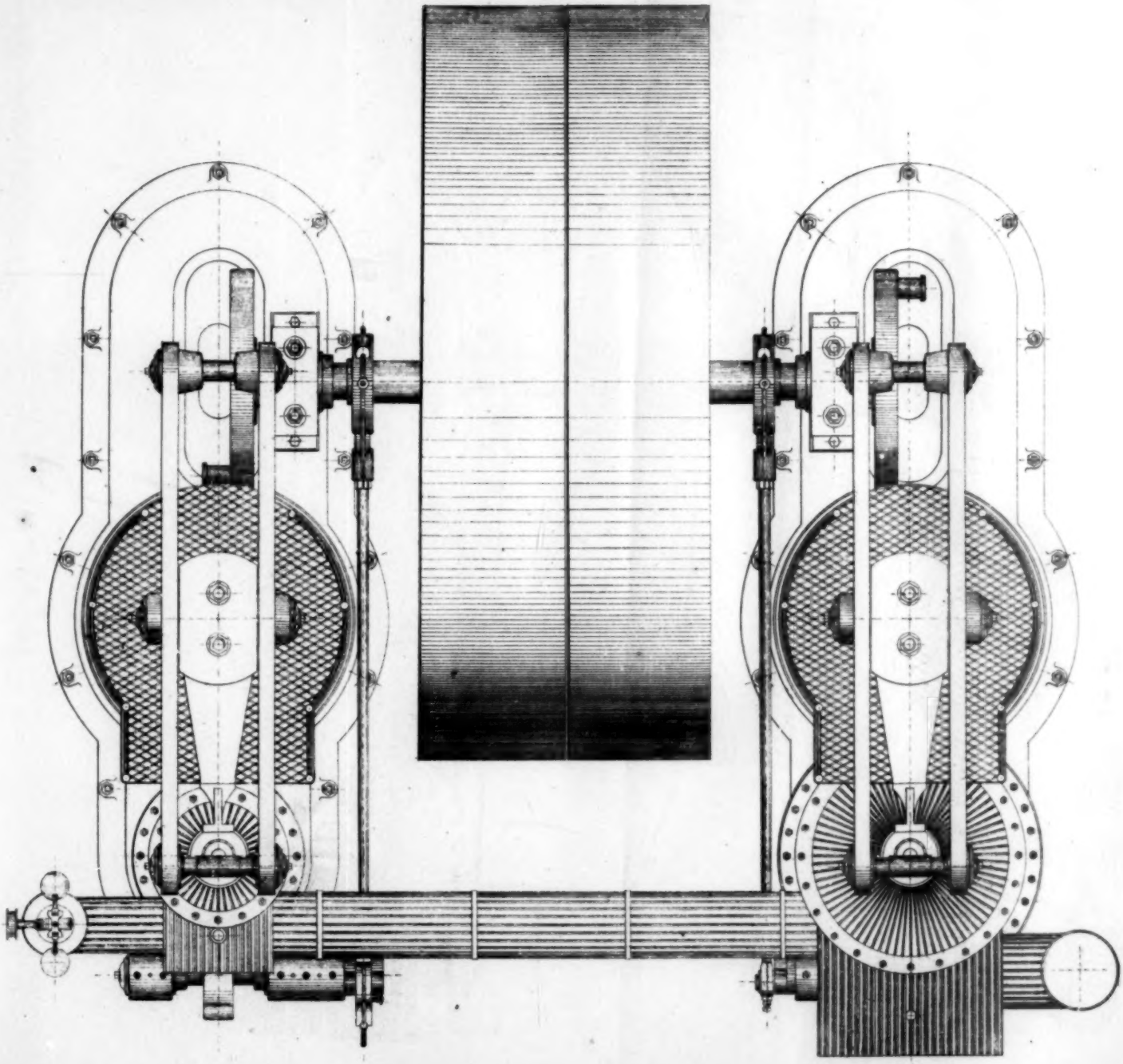


cured in any position thereto by adjusting screws. Each box can be raised vertically as may be necessary by wear from time to time. Any desired plane of vibration for the beam can thus be obtained by simple means of adjustment. The cylinders are cased with walnut staves, held in place by polished nickel bands, and are placed at such height that all water of condensation in the steam-pipes is returned to the boilers.

A feed water heater of unusually large dimensions forms part of the exhaust pipe between the low pressure cylinder and the condenser, and serves the double purpose of heating the feed and partially condensing the steam—a plan which was deemed necessary in this case, as the water used for injection is mixed with the waste liquors from dye-houses, and is not fit to be used again for feed.

The heater, condenser, and air and feed pumps are placed below the engine room floor. Steam is supplied by twelve plain cylindrical boilers, 36 inches diameter by 36 feet long, in nests of three each.

These engines were designed and built at the "People's Works," corner of Front street and Girard avenue, Philadelphia.

THE CLEVELAND WATER-WORKS TUNNEL.*

The announcement of the fact that the water-works tunnel is completed throughout its entire length, will be received by all our citizens with unalloyed satisfaction. It will insure to the city, for an indefinite period in the future, an abundant supply of good water, free from the nauseous impurities caused by the drainage of oil refineries, slaughter-houses and sewers, which have at times rendered the water almost totally unfit for domestic use. The new dispensation which is just dawning upon us has long been eagerly looked for, and very many of our citizens had begun to lose faith in the success of the tunnel project. Month after month and year after year passed, and much of the time but slow progress was made, with an occasional accident that threatened disastrous results, and the unpleasant idea was gradually taking possession of the public mind that the enterprise would fail, that two or three hundred thousand dollars would be thrown away, and no relief afforded from the noxious liquid that we had been compelled to use under the name of water. But the engineer, John Whitelaw, Esq., the contractor, A. A. McDonell, Esq., and the Water Commissioners, have been steadfast in the belief that success would at last crown their efforts, and now they have their

* Cleveland Daily Herald, Oct. 13, 1873.

reward, after years of anxiety and labor. In this connection a brief history of the enterprise will be read with interest by many.

The necessity of a supply of pure water had long been felt. The complete success of the Chicago water-works tunnel induced the belief that a similar plan was the only means that would give to Cleveland the needed relief. Borings were carefully made to ascertain the character of the ground under the lake. For the depth of forty feet or more, at all points a hard blue clay was found, which was in the highest degree favorable for the work. Had it not been for subterranean springs and quicksands which were encountered at various points, and which at times seemed to make the result doubtful, the tunnel would doubtless have been completed a year and a half ago.

The shore shaft was sunk in the fall of 1869, the work being commenced in August of that year. After going down about eighty-five feet, the lateral excavation was begun, and continued some three hundred feet. Up to this point the work was done by the Water-Works Department, under the direction of the Commissioners. The object was to decide, by actual test, the feasibility of the project, and afford a basis for proposals to do the work by contract. When this had been, apparently, fully demonstrated, bids were invited, and the contract was subsequently awarded to A. A. McDonell, Esq., of Chicago. Many a man not possessing his indomitable perseverance, determination and "pluck" would have abandoned the enterprise long ago, in the face of all the unexpected dangers and disasters he encountered, involving very heavy outlays of money which had not entered into his calculations.

The Shore Section.—The work progressed favorably for over a year. At one point a quicksand made its appearance, requiring the abandonment of a considerable length of finished tunnel. A long curve was made around this obstruction, and all went well again. At a point about thirty-nine hundred feet from the shore, a large and extremely troublesome quicksand was found, which proved a most serious obstacle, and forced the suspension of work at that end. The whole section filled with water and was allowed to remain so for nearly two years, while the excavation was in progress from the other end.

The crib is an immense wooden structure, formed of heavy timbers fastened together in the strongest possible manner. It is pentagonal in form, with a mean diameter of eighty-five feet, each of its five sides being fifty-four in length. This was built on shore, by the

Messrs. Delamater, in the summer of 1870. It was successfully launched and towed out to its resting place, six thousand six hundred feet, or just one mile and a quarter, from the shore. Here it was securely anchored by hundreds of tons of stone, packed in and around it, and to-day it stands as immovable as Gibraltar, the fiercest winds and waves having not the slightest effect upon it. A building made of heavy oak plank, to resist the force of the elements, stands upon the crib. It has been largely occupied by the machinery and apparatus for carrying on the work, but will now be fitted up with comfortable rooms for the occupancy of the "keeper," whose home it will be. It will be readily understood that during the season of navigation a light must be kept upon the crib as a guide and warning to vessels. Although not perhaps in all respects as desirable for a residence as a place on the "Avenue," to an average family, it is not without its partially compensating features.

The Lake Section.—The shaft in the center of the crib was sunk to the distance of ninety feet below the surface of the water. This is some twenty feet lower than the bottom of the shore shaft; but it was found necessary to descend to that depth on account of a stratum of soft clay, through which the tunnel could not be excavated without great expense and danger. The work of pushing the tunnel shoreward was then undertaken with vigor. The proper course was given by the engineer, Mr. Whitelaw, who, as in the shore section, made frequent visits to the tunnel with his instruments for that purpose. Let the reader imagine these two sections, one thirty-nine hundred and the other twenty-seven hundred feet in length, from forty to seventy feet below the bottom of the lake, with the respective starting points a mile and a quarter apart, with a rise of over twenty feet from the foot of the crib shaft, and with sundry curves and turns to avoid quicksands, and he may be able to form some faint idea of the marvellous mathematical skill necessary to bring the ends together, nearly midway between the crib and the shore. It can easily be seen that a deviation "in the estimation, of a hair," at either end, in the vertical or lateral direction, would carry them very far from each other, and the toilers might dig away in there for a lifetime without "making both ends meet." But so exquisitely perfect and accurate are the instruments used, and so masterly the skill and understanding of him in whose hands they were, that the junction was made on Saturday in the most perfect manner. The sections met on an exact level, and when the mason work was finished no person could detect

the point at which the connection was made. Although he had implicit faith in his calculations, yet, realizing what must have been the inevitable result of the slightest error, he could but experience a feeling of satisfaction and relief when the miner's pick struck through, and the point was reached where work had been stopped from the other end, nearly two years before.

One million seven hundred thousand brick were used in the construction of the tunnel. These are of the hardest kind, and laid in a cement that when "set" is as hard as the brick itself. The capacity of this tunnel is from sixty to seventy million gallons of water daily. When the fact is stated that the present average daily consumption of water is about six million gallons, it will be seen that the tunnel will be ample to supply Cleveland when it shall have a population of a million.

ON THE SELECTION OF A BUILDING STONE.

By C. A. Evans, Civil Engineer.

This is a subject which has been under the pen of most writers on construction. Yet, notwithstanding this extensive treatment, no general principles have been indicated to direct the selection of a stone for an intended structure. To the engineer, in particular, the selection of materials suitable to the variety of works he executes, is a matter, the importance of which, is of itself evident. It is to elucidate the principles which should guide him in this portion of his labors, that this article has been written.

A continual practice in one direction by reason of some prominent good quality which a stone may possess, often prejudices many builders in favor of the particular class to which it belongs. But an extensive experience in all countries leads to the conclusion that a perfect stone is one which has several good qualities; which is strong, durable, capable of being ornately worked, and of a fine appearance. For engineering works situated in the country, strength and durability are the only points which need be considered. Nevertheless, it is often difficult to obtain a stone which will fulfil even these two requirements. How a stone stands in regard to them, may be determined as accurately as the usual tests admit. No test for durability, however, has yet been discovered which may be implicitly relied upon; yet no known test relating to this point should be omitted by the engineer

if he would remove from his shoulders all blame of future *accidents*. A thorough examination of a stone, comprising that of its quarry, of its structure, of its constituents, leads generally to correct results. The plain character of engineering works in the open country, with their architectural effect depending only upon the proportion and disposition of their masses, does not require stones capable of being dressed as elaborately as those for city structures. For this reason this quality does not play here an important role. As regards appearance, it may be remarked, that the surroundings are usually in harmony with it, of whatever color and texture the stone may be. Therefore, even if circumstances did not compel the engineer to employ the most accessible stone, paying attention only to strength and durability, there would really be no necessity to consider anything else. On approaching a large town, however, regard must be had to *all* the foregoing qualities. The class of work now changes. Here are located shops, depots and dwellings. These will be in contrast with other buildings, and show to advantage or not, according to the good or bad choice of their material. The architectural principles which here govern the engineer become more complicated and numerous, and demand, in consequence, a fine stone. Nevertheless, all should not be sacrificed to architectural considerations. Financial matters demand reflection. It would not be wise to draw from distant sources such a stone, when a good one, though inferior in structure and appearance, exists in the neighborhood. In such a case, the engineer must put up with what nature offers him, and employ a style of architecture which will be most in keeping with his material. But in cities a handsome depot demands a handsome stone. If no quarries in the vicinity furnish it, recourse must be had to others more remote. The expense may be considerable, but it must be borne in mind that an ugly material will make a building doubly so, especially if large and surrounded by better architecture. Should a fine stone not be offered, let brick then be used in preference to an inferior one. Some respect should be paid to the requirements of art.

In selecting a stone for an intended structure in a city, we must be governed in our choice particularly by a consideration of the class of onaments which are to appear on the building, and by the expression which it is to possess. If the structure is to be decorated with plain large mouldings of a bold outline, then a coarse grained and dark stone may be used. But should it, on the contrary, be embellished with delicate carvings, or with small figures in relief, either on the

mouldings or the plain wall, a light-colored and close-textured stone is required. No dark or coarse-grained stone should be employed in this latter case. For a dark stone will fail to make the shade and shadows of these small ornaments perceptible, thus greatly diminishing their effect. A coarse-grained stone will not admit of fine edges being cut on it, and it is only by such luminous lines that we are enabled to clearly define the shape of the ornaments. For the want of either shade or luminous lines, small figures in relief will often, when viewed from no great distance, appear like lumps raised on the surface of the stone. This is particularly the case after the building has stood for a number of years. On a new building everything is clean. The stones are lighter than the permanent color they will finally assume under the influences of the air, dust and smoke. But the most powerful agent of destruction is the humidity of our climate, under the attacks of which all stones succumb more or less. This is easily perceived on examining their edges. Such an examination will also show that a coarse-grained stone exhibits more plainly the marks of these attacks than a fine-textured one. The particles are comparatively large, and those which are removed leave correspondingly large vacant spaces. Hence it is wrong to carve on such a stone, whatever may be its merits in other respects. Twenty winters will often be sufficient to destroy the edges of ornaments on a coarse-grained stone of great durability. These effects are noticeable particularly when the stone is situated in a place exposed to the prevailing winds and rains, whether in the streets of a city or the open country.

The preceding is a fundamental rule in architecture, yet it is constantly violated. When decoration in a high degree is intended, marble is the most appropriate stone for this class of work. The turn of a leaf carved out of this stone may be distinctly seen placed at the summit of a spire. For the material retains its sharpness of contour, its edges reflect the light, and its shades are visible and effective. In nothing more did that fine race, the Grecians, show their exquisite taste than in the choice they made of this material for their edifices.

Passing now to consider a stone with reference to the expression which its color may communicate to a building, it may be laid down as a general rule, that a light-colored stone is adapted to nearly all buildings, whether of a massive or light, a magnificent or plain character. But structures intended to have a sombre appearance should be built of the darkest stone procurable. Nevertheless, if they are not well designed, the full effect of such a stone will not be brought out.

This material may be used also in combination and contrast with lighter stones, producing quite a picturesque effect. Grandeur of style, however, demands a sameness of color. A medium dark stone gives an air of repose to a building built with it. Still, it should be used either in open situations or in those in which it may receive plenty of light. Hence a narrow street may be considered as an unfavorable situation for its employment.

The finest light-colored sandstones are doubtless those best suited to city purposes. A *good* limestone is also a fine stone in every respect. Some varieties of this stone preserve their color very well. For, being smooth, the dust does not much adhere to them. Many argillaceous stones, on account of their slaty structure, are disagreeable to work, yet they may be advantageously employed. A coarse-grained granite is open to the objections frequently urged against all coarse-grained stones, though some fine-grained varieties, obviating these inconveniences, make fine building stones for moderately decorated structures. But, in general, granites become quite dark with age; and, for close views, as those obtained in a street, they are not, in the opinion of the writer, as effective in appearance as stones the constituents of which are all of an uniform color. For many of the plain works of the engineer, granite may properly be considered as the most desirable material. In basements, particularly in those of depots, it may be introduced on account of its not showing the grease as much as some other light-colored stones. Under the name of granite is here included also that stone known to writers on mineralogy as syenite, and which is especially referred to in the foregoing remarks.

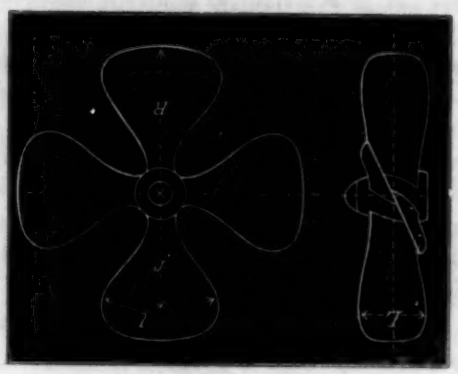
Philadelphia, Oct. 2d, 1873.

St. Gothard Tunnel.—During the month of July the following progress was made at the tunnel: At the west end, at Gœschnen, the length of heading driven during the month was 51 metres, making a total of 259 metres driven up to July 31st. The length of tunnel completely excavated was increased from 150 to 200 metres at that end. At the south end, at Airolo, 47 metres of heading were driven, making a length of 266 metres driven up to the end of July. The length of tunnel completely opened out was increased from 214 to 253 metres. The average number of workmen employed during the month of July was 945, and the greatest number employed at the works in one day was 1159.

ON FRICTION OF SCREW PROPELLERS WORKING IN WATER.

By John W. Nystrom, C. E.

The friction of screw propellers running in water is a considerable item of the propelling power, and is well worthy of attention when speed of the vessel and economy of fuel is desired. The solution of the problem furnishes a good example of the value of the calculus in dynamics.



Notation of Letters.

P = pitch of the propeller in feet.
R = radius of the propeller in feet.
r = any radius less than R.
l = length of a helix for one whole convolution in feet, at the radius r.
A = area of the helicoidal surface for one whole convolution in square feet.
N = number of blades of the propeller.
n = number of revolutions per minute of the propeller.
v = velocity of the helix l in feet per second.
h = horse-power of friction.
f = friction in pounds.
δ = differential.

The friction in pounds per square foot of surface of cast iron and brass, of rough castings and also of smooth surfaces, filed or ground but not polished, is as follows, when the surface moves with the velocity of one foot per second:

Friction Surface.

	f'
Rough cast iron, ...	0·0045
Smooth cast iron, ...	0·0040
Brass, rough casting, ...	0·0040
Brass, smooth surface, ...	0·0030

The friction for rough cast iron will then be, in pounds,

$$f = 0{\cdot}0045\ \mathrm{A}\ v^2. \qquad 1.$$

The differential area of the helicoidal surface for one convolution will be

$$\partial \mathrm{A} = l\ \partial r,$$

and the differential friction

$$\partial f = 0{\cdot}0045\ v^2\ l\ \partial r, \qquad 3.$$

when the differential horse-power will be

$$\partial h = \frac{0{\cdot}0045\ v^3\ l\ \partial r}{550}. \qquad 4.$$

The velocity $v = \dfrac{l\,n}{60}$ and $v^3 = \dfrac{l^3\,n^3}{60^3}$. 5.

The differential horse-power will then be

$$\partial h = \frac{0{\cdot}0045\ n^3\ l^4\ \partial r}{550 \times 60^3}. \qquad 6.$$

Call $\mathrm{X} = \dfrac{0{\cdot}0045\ n^3}{550 \times 60^3} = \dfrac{n^3}{26{,}400{,}000{,}000}$. 7.

Then $$\partial h = \mathrm{X}\ l^4\ \partial r, \qquad 8.$$

and $$h = \mathrm{X} \int l^4\ \partial r. \qquad 9.$$

But $l = \sqrt{4\ \pi^2\ r^2 + \mathrm{P}^2}$, and $l^4 = (4\ \pi^2\ r^2 + \mathrm{P}^2)^2$. 10.

Insert formula 10 in formula 9, and we have

$$h = \mathrm{X} \int (4\ \pi^2\ r^2 + \mathrm{P}^2)^2\ \partial r. \qquad 11.$$

$$(4\ \pi^2\ r^2 + \mathrm{P}^2)^2 = 16\ \pi^4\ r^4 + 8\ \pi^2\ r^2\ \mathrm{P}^2 + \mathrm{P}^4. \qquad 12.$$

Then $$h = X \int (16\,\pi^4\,r^4 + 8\,\pi^2\,r^2\,P^2 + P^4)\,\delta r. \qquad 13.$$

By integrating each term in the parenthesis we have

$$h = X \left(\frac{16\,\pi^4\,r^5}{5} + \frac{8\,\pi^2\,r^3\,P^2}{3} + r\,P^4\right) + C. \qquad 14.$$

$$\frac{16\,\pi^4\,r^5}{5} = 311{\cdot}71\,r^5, \quad \text{and} \quad \frac{8\,\pi^2\,r^3\,P^2}{3} = 26{\cdot}319\,r^3\,P^2. \qquad 15.$$

Integrate the friction horse-power from the centre of the propeller to the periphery of radius R, then when $r = 0$, $C = 0$.

Insert the formula 7 for X in formula 14, with the values 15, and we have the frictional horse-power for one convolution of the screw and for one side of the helicoidal surface,

$$h = \frac{n^3\,R}{26{,}400{,}000{,}000}\,(311{\cdot}71\,R^4 + 26{\cdot}319\,R^2\,P^2 + P^4). \qquad 16.$$

The helicoidal surface of screw propellers is generally cut up into small portions by a number of blades, each of a fraction of the pitch, and when the helicoidal surface is counted on both sides of the blades, the friction horse-power will be

$$h = \frac{R\,L\,N\,n^3}{13{,}200{,}000{,}000\,P}\,(311{\cdot}71\,R^4 + 26{\cdot}319\,R^2\,P^2 + P^4). \qquad 17.$$

This formula includes both the dragging and rotary friction horse-power of a propeller of rough cast iron.

Call f' = friction in pounds per square foot of surface moving with a velocity of one foot per second, and the friction horse-power will be

$$h = \frac{f'\,R\,L\,N\,n^3}{59{,}400{,}000\,P}\,(311{\cdot}71\,R^4 + 26{\cdot}319\,R^2\,P^2 + P^4). \qquad 18.$$

Example.—Required the friction horse-power of a propeller of the following dimensions:

Diameter of propeller, 20 feet, or .	$R = 10$ feet.
Pitch, ...	$P = 40$ "
Length in the direction of axis, . .	$L = 4$ "
Number of blades, . . .	$N = 4$.
Revolutions per minute, . .	$n = 50$.

The horse-power consumed by friction will then be, for rough cast iron surface,

$$h = \frac{0{\cdot}0045 \times 10 \times 4 \times 4 \times 50^3}{59{,}400{,}000 \times 40} (311{\cdot}71 \times 10^4 + 26{\cdot}319 \times 10^2 \times 40^2 + 40^4) = 374{\cdot}528 \text{ horses.}$$

In the year 1850 an experimental steamer was built in Kensington, Philadelphia, which was expected to make 20 to 30 miles per hour. The propeller was about 4 feet in diameter, with only one blade extending the whole convolution of the circle, and with a very fine pitch of about 6 inches. (The author does not remember the exact dimensions). The propeller was expected to make 500 revolutions per minute.

Example.—Required the friction horse-power of the above-described propeller. R = 2 feet, P = 0·5 feet, n = 500, L = 0·5, N = 1. Surface, rough cast iron.

$$h = \frac{0{\cdot}0045 \times 2 \times 0{\cdot}5 \times 0{\cdot}5 \times 500^3}{59{,}400{,}000 \times 0{\cdot}5} (311{\cdot}71 \times 2^4 + 26{\cdot}319 \times 2^2 \times 0{\cdot}5^2 + 0{\cdot}5^4) = 95 \text{ horse-power, nearly.}$$

The power of the engine, counted from the size of the steam boiler, did not amount to more than 50 horse-power, and the result was that when the trial trip came off the steamer could hardly crawl up against the tide.

The building of the steamer, was kept in the greatest secrecy, and her performance was expected to astonish the world.

There was another experimental steamer built in Kensington in the year 1864, in which several curious propellers were placed on each side of the vessel, which also turned out a failure on account of the friction of the propellers in the water being too great.

New Reducing Agents.—When water, saturated with sulphurous acid gas, is allowed to act upon zinc powder, the metal dissolves without the emission of gas, and the liquid becomes of a pale yellow color, and possesses, in a high degree, the power of dissolving indigo. Schützenberger has lately been investigating this subject, and finds that this decolorization is the result of reduction. The liquid above-mentioned, in its free condition, is extremely unstable; but if a concentrated solution of bisulphite of soda is allowed to act upon the zinc powder, a soda salt of the new acid is obtained, which possesses reducing powers not less remarkable than those of the free acid itself.

Chemistry, Physics, Technology, etc.

A DEVICE FOR DEMONSTRATING THE LAWS OF THE CENTRAL FORCES.

By Prof. A. E. Dolbear.

The want of definiteness in the conditions under which experiments are usually made with the common turning-table, especially when applied to the demonstration of the laws of the central forces, has led me to devise the following modification of the apparatus for this work. The performance is good, and I therefore submit a description of it, for the benefit of those who teach mechanics, and especially for those who may study it in any of the various physical laboratories.

The usual form of apparatus for this work, as it is constructed by instrument makers, is too well known to be described here. The subjoined figure will sufficiently well indicate the modification so that any one possessing the common arrangement for raising a weight by the centrifugal force of a ball running upon a wire, can adapt his instrument to it. The frame work *a*, which is screwed to the shaft, has the upright posts *b b*, and the frame *c*, having a wire stretched upon it for the ball, *e*, to move upon. Instead of the usual weights to be raised I substitute a common spiral spring balance, *d*, which hangs from the top bar and is connected to the ball by a stout string tied to its hook, passing round the small pulley at the bottom and thence to the hook upon the ball.

It is evident that when the ball, *e*, moves toward the end of the wire the index of the scale will indicate the number of pounds pull. When the machine revolves the ball is driven outward, and of course pulls upon the scale, which in turn directly points with its index the number of pounds, or, in other words, the centrifugal force. It may be thought that when the scale itself is turning fast the index could not be seen; but, if one stands in such a position that the light from a window or a lamp will be reflected from its face to him, the index

and figures can be plainly seen, no matter how fast it goes. The radius of the circle described by the ball, *e*, can be found by adding to its distance from the centre of revolution, when at rest, the measured distance from zero on the scale to the number of pounds indicated. Then, if the weight of the ball itself is known, all the data for the demonstration are had at once. This form will easily permit of graphical construction for the results, which is quite an advantage for a learner.

CONVECTION APPLIED TO THE DETECTION OF HEAT.

From a Lecture on "The Sources of Heat."

By L. C. Cooley, Ph. D.

I have been thus careful to fully illustrate the production of air currents by changes of temperature in order that I may freely use this principle of convection to make visible to us all the delicate phenomena by which I hope to illustrate the fundamental principles in the science of heat.

Let me describe the instrument by which this novel application is made. You would, no doubt, at first view, pronounce it a form of Coulomb's Electrometer. You observe the slender needle suspended horizontally in this glass case, but you cannot observe the exceedingly delicate silk fibre by which it hangs. This needle is a glass tube. It was made by taking a very much larger glass tube and, in the usual manner, drawing it out to this degree of fineness. It is about four and a half inches in length, and carries a pith ball at one end. This pith ball is blackened—it was rolled in dry lampblack—that it may be more easily seen. The needle, with its pith ball, together with the necessary cement and the varnish which covers it, weighs nearly one and a half grains. Just below the needle is a horizontal disk, the circumference of which is graduated, and the centre of which, when the instrument is level, is exactly in the prolongation of the vertical fibre which sustains the needle. In the cover of the glass case, and just over the zero of the scale below, is an opening through which a body may be thrust when we would bring it into the neighborhood of the pith ball. The motion of the needle will declare the presence of heat or cold. Here is a copper wire which I hold in my hand, and while uttering this sentence I am pressing the end of it gently against my face. Let me thrust it down upon the zero of the disk, the pith ball now standing at 20° away. The needle begins to swing. You

see the pith ball slowly approaching the warmed wire; in half a minute more you see the two apparently in contact. Our first impulse is to declare the presence of electricity; our second is to test the truth of such a declaration.

I will join this copper wire by means of this chain to the chandelier which hangs above me, and now, holding it with these wooden pincers, I repeat the experiment. The conducting communication with the earth forbids the accumulation of any electricity in the wire, and yet you see the needle slowly swinging as before. I might make other experiments, if more were needed, to convince you that it is not electrical attraction which moves the ball. It is heat. The scorched air, above a burning temple, rises, while the surrounding atmosphere flows in to feed the flames. In this little instrument you see the action of the same principle in a milder mood. The warmed wire imparts heat to the air in contact with it. This warmed air rises, while that surrounding it on all sides flows in to take its place, and the pith ball is wafted toward the wire by the gentle breeze.

You have already seen the application of heat producing powerful air currents toward the centre of disturbance. Heat and convection are a cause and its effect. Either being sensible, under proper conditions, the presence of the other may with certainty be inferred. Hence convection currents become a test for the presence of heat, or, more correctly, they declare the occurrence of a change in temperature. But the delicacy of this test is, perhaps, greater than our intimacy with convection currents would lead us to expect. Yonder is a beam of sunlight streaming through the window-shutter. I will cut its pathway with a mirror, and thus throw it against the side of the glass case of our thermoscope, directing it upon a point, it may be, 30° away from the pith ball. The beam will warm the glass. We must wait until the heat has passed its thickness. The air in contact with the glass within will then be warmed; convection currents will be occasioned, and the motion of the needle will make them visible. Already the motion of the pith ball can be seen distinctly. Such delicacy as it possesses is, for occasions like the present, an obstacle to its use. Before I can continue my experiments with the instrument, I must wait for the glass to part with the heat it received from the sunbeam. The heated portion of the glass fetters the needle, and prevents its response to the gentler solicitation of other objects. But in the meantime let me turn my sunbeam upon the bulb of an air thermometer. We wait until the thin glass is warmed; still, at our dis-

tance we can discover no motion of the fluid in the stem. This sunbeam may be as cold as one of moonlight for aught the air thermometer informs us to the contrary. Doubtless the air within the bulb has expanded; by a closer examination of the scale I can perceive the degree, but you will no doubt all agree with me that for our purposes, convection is a better detective than expansion.

Placing a copper wire upon an anvil, I raise a hammer to the height of a foot above it and allow gravitation unassisted to pull it down. After the collision I quickly but carefully thrust the wire into the neighborhood of the pith ball. The slow swing of the needle toward it announces to us all that the wire was heated by the blow. The motion of the mass of iron became suddenly a motion of the molecules of copper, and in their thermal tremor is the equivalent of the force of gravitation which brought the hammer down.

I take another similar wire and find, by thrusting it into the thermoscope, that it has no power to move the needle. Let me now press it gently upon the cold table-top and at the same time make a few rapid passes back and forth over its surface. Quickly introducing it to the pith ball, we see the needle speedily spring toward it. The metal has been warmed by the friction. The visible motion caused by my muscular effort in rubbing the wire, became an invisible tremor of the molecules of the metal, and reappears finally in the visible movement of the needle.

Taking another wire, whose temperature has not been disturbed, and which we find unable to awaken any response in the thermoscope, I place the end of it between the smooth jaws of a vise and press it severely by a turn of the screw. Transferring it without delay to the thermoscope, we see the pith ball, by its approach, announcing the evolution of heat by the pressure.

Blows, friction, and pressure are the three forms of *mechanical action*. The three experiments just made are typical. Together, they illustrate the truth, considered demonstrated by multitudes of phenomena in each of the three classes, of which these experiments are types, that no mechanical action occurs without the evolution of heat. Incidentally, these experiments also afford us a set of most beautifully simple illustrations of the curious and facile transformations of motion, so constant and so important in the economy of nature.

I now take two liquids—a thimbleful of oil of vitriol and a fourth part as much of water. I will show you first that the temperature of these liquids is the same as that of the air within the thermoscope.

While still moist with liquid, I plunge these two wires successively into the glass case; the needle responds to neither. But now I mix the liquids, and I plunge a wire into the mixture. Let me next thrust the moist wire into the instrument. See how quickly the needle responds. Its motion toward the wire declares the presence of heat therein.

But what is the origin of this heat? No friction, no percussion, no pressure which the senses can detect. The action is molecular. So strong is the attraction between the molecules of the two liquids that they leap the interval which separates them, and, like cannon balls flying from opposite directions, they strike each other. The collision shatters them, and while their atoms seek a closer combination, this thermal tremor throughout the mass goes on. The almost infinite number of collisions balances the almost infinitessimal value of a blow, and we are able to detect the heat generated by the aggregate percussion with greater facility than we can that evolved by the blow of a hammer.

But notice, it was not the heated liquid; it was the heated wire which the pith ball of the thermoscope approached. The wire received a portion of heat from the liquid and again imparted it to the air within the instrument. But in the light of our philosophy what is this transference of heat? We are taught to consider the liquid and the wire to be in the condition of two bodies in contact, with different rates of motion. The greater velocity will be reduced, and the lesser one increased until the two motions shall be equalized. Were our eyes endowed with more than microscopic vision while the wire is being heated, we could doubtless see a countless multitude of little molecules of liquid swinging against the multitude of more sluggish molecules of metal, and urging them to greater speed.

Such an invisible transfer of motion occurs whenever two bodies of unequal temperatures are brought together. It is easy to detect the loss of molecular movement in the one, as the gain of it in the other. I take this wire and plunge it into ether. It emerges from its bath moist with the liquid. A gentle rise of temperature converts this film of ether into vapor. On simple exposure to air it evaporated. The heat for this purpose is taken by the liquid from the metal and the wire becomes in the same proportion colder. I carefully thrust the wire into the thermoscope, and *the needle swings away from it* as if controlled by a strong repulsion. Announcing the pressure of heat in our former experiments by approaching the wire, it now announces

the reduction of the temperature of the metal by receding from it. Picture to yourselves the molecular motion of the wire and of the air which surrounds it. Notice that the thermal tremor in the air is more violent than in the metal, and that it must be, therefore, checked by contact. But this checking of its molecular motion is, in familiar phrase, the cooling of the air. This cold air, heavier than that which surrounds it, responds to the attraction of gravitation, and, falling, pushes the air on all sides away. Air currents from the wire, like the land-breeze from an island at night, are occasioned, and, feeble as they must be, they are strong enough to show their presence. You saw the frail needle of the thermoscope wafted by the gentle wire-breeze.

Thus this tell-tale needle is ever ready to respond to either heat or cold. Careful to protect it from all outside thermal disturbances, we may question it with the utmost confidence that it will declare correctly whether an object is warmer or colder than the air in which the needle is suspended. We are to place it upon the side-table for a season only to have recourse to it again in our future study of other parts of the science of heat. It has silently responded to many of my silent questions, privately, during the two years past, whether to those of any person else, I know not; indeed, I must own my ignorance of the existence of another convection thermoscope.

A NEW OPTICAL TOY.

By Prof. A. E. Dolbear.

While seeking for a method of projecting the phenomenon of manometric flames, I stumbled upon the following interesting and instructive device, which is so easily made and presents such optico-acoustic effects that I thought it worth the attention of every one who is engaged in physical experimentation. That a thin membrane will vibrate from the pulsations of air due to sound-waves has been known a long time, and many interesting experiments have been devised to show this. König's Manometric Flames and Scott's Phonautograph are based upon this property, and are among the latest inventions for illustrating it. They are both rather complex and costly, and can be had but by a few. This apparatus of mine can be made for two cents or less, and with it almost everything that can be shown with the two named instruments can be shown, and more, many of the finest illus-

trations of tuning-forks, namely, the Lissajous curves, are exhibited on the largest scale.

But to the instrument. Take a tube of any material, from one to two inches in diameter, and anywhere from two inches to a foot or more in length. Over one end paste a piece of tissue paper or a thin piece of rubber, or gold-beaters' skin; either will do. In the centre of the membrane with a drop of mucilage fasten a bit of looking-glass not more than an eighth of an inch square, with the reflecting side outward of course. When dry, take it to the sunshine and with the open end of the tube at the mouth, hold the other end so that the beam of reflected light will fall upon the white wall or a sheet of paper held in the hand. Now speak, or sing, or *toot* in it. The regular movement of the beam of light with the persistence of vision presents very beautiful and regular patterns, that differ for each different pitch and intensity, but are quite uniform for given conditions. If a tune like Auld Lang Syne is tooted slowly in it, care being taken to give the sounds the same intensity, a series of curves will appear, one for each sound and alike for a given sound, whether reached by ascension or descension, so that it would be possible to indicate the tune by the curves; in other words, it is a true phonautograph.

By trial one can find some tone which causes the membrane to vibrate in a single plane, and of course a straight line will appear upon the screen. If, while the sound is continued, the tube be swung back and forth at right angles to the line, the sinuous line will appear, which may be either simple, representing a pure and simple sound, or it may be compound sinuous, showing over tones, precisely as in König's manometric flames.

With the lecture room darkened and using the beam of light from a porte lumeire or from a lantern, these may be projected of an immense size. There is no trouble in the world to make them eight or ten feet amplitude or more if needed. At a distance of but three or four feet the curves will spread out to two or three feet in length when a tone is made to which the tube can reasonably respond.

The music that one will make with such a musical instrument will not be likely to find favor among musical critics, for it savors very much of the paper and comb sort, such as the unsophsticated ear of a ten year old boy is fond of, but it may be endured for a few minutes in view of its residual excellencies for illustration and demonstration. It is worthy of a good name in the great scope family, and I christen it Opeidoscope.

AMERICAN MACHINERY ABROAD.

The great industrial exhibition at Vienna is now drawing to a close, and by the time the lines we now pen are presented to our readers, it will have become a thing of the past. Unfortunately, America's part in this World's Fair was, by no means, worthy of her acknowledged position as a manufacturing nation; from all accounts it appears that our industries were but meagerly represented; yet, small as this display may have been, the unusual interest, the practical utility and beauty of many of our exhibits, made the American Department a centre of attraction for all in any way interested in the progress of the mechanic arts. Our claim to distinction in this important division of the world's industry is rapidly becoming established; American thought, American inventive skill, find a recognition and a hearty approval among the educated mechanics of every land. The European engineer carefully watches our progress, and endeavors eagerly to avail himself of our discoveries; thus, although Mr. Corliss did not exhibit a single engine at Vienna, such was the celebrity of his inventions, and so wide-spread their influence, that he was awarded a Diploma of Honor, inasmuch as many of the steam motors displayed by European makers were of his type. This Diploma of Honor, we learn, "was designed to bear the character of a peculiar distinction for eminent merits in the domain of science, and its application to the education of the people and the advancement of the intellectual, social and material welfare of man;" and was awarded "exclusively by the Council of Presidents upon the proposition of the International Jury."

One of the largest and finest displays, in the American Machine Department, was from Philadelphia; and to this we now wish to direct attention—we allude to the machines sent by Messrs. Wm. Sellers & Co. It pleases us to learn that the work of this Philadelphia house has, like the Corliss Steam Engine, been extensively copied abroad, and, what is equally gratifying, that its great practical value has been publicly attested by the same peculiar distinction. The exact words in which the group jury recommended that the Diploma of Honor be awarded, in this instance, were as follows:

ORIGINAL:

"*Sellers.*—Wegen besonders hevorragenden Leistungen in Erfindung und Fabrikation von Werkzeug Machinen, die zum Theil den Constructeuren aller Länder als Vorbilder gedient haben."

TRANSLATION:

"*Sellers.*—For pre-eminent achievements in the invention and construction of machine tools, many of which have been adopted as patterns by the constructors of tools in all countries."

To fully appreciate this award and the considerations that prompted it, we must call to mind that, in the French Exposition of 1867, this house, in common with other American machine-tool builders, displayed a large amount of machinery, which attracted considerable attention abroad and found a ready sale. Commenting upon these tools, Prof. Reuleaux, Director of the Industrial Academy of Berlin, in his report on Motors, Machines and Machine Apparatus, at the Paris Exposition, writes thus:

"Upon the field of inventions and of inventive genius, there were but few highly remarkable achievements present, and among these America held the first rank. Her machine exhibition bore almost exclusively the character of originality, and, although the execution was not generally superior, it contained examples of the highest order of constructive ability and perfect workmanship." "France and England offered less original matter—more than both perhaps Germany and Switzerland——"

"Upon the whole it may be said that in machine industry England has partly lost her formerly undisputed leadership, or that she is at least about to lose it. The healthy young trans-atlantic industry, which continually withdraws from us energetic and intelligent heads and robust hands, makes, with the aid of her peculiar genius, the most sweeping progress, so that we shall soon have to turn our front from England westward."

"Newly devised motors, forming part of complete machines and models of distinct parts, exhibited as novelties or inventions, were numerous. In the first direction Sellers & Co., of America (Philadelphia), have accomplished the most. The constructions of Sellers, some of which have very rapidly made their way through Germany, bear, in regard to invention, the peculiar, unique stamps of American genius. They are distinguished from us by more direct and rapid conception. The American aims straightways for the needed construction, using the means that appear to him the simplest and most effective, whether new or old. Our historically heaped up material and the cautious character of the German are so inseparably interwoven that among the number of known means we often forget to ask whether they are the simplest or whether new ones might not be better. The American really constructs in accordance with the severest theoretical abstraction; observing on the one side a distinctly marked out aim, weighing on the other the already available means or creating new ones, and then proceeding, regardless of precedents, as straight as possible for the object. This spirit is manifest in Sellers' lathes, shaftings and bearings, in his planing machine with diagonal screw shaft, in his screw cutting machine; and it is strikingly prominent in his system of screw threads, which he has boldly placed alongside of the old venerated Whitworth system, in spite of the terror of its numerous adherents, after he had discovered actual deficiencies. A proper valuation of this proceeding contains the most instructive hints for our higher technical institutions."—*Public Ledger, October 4th.*

It will be thus seen that the peculiar originality of design and boldness of execution displayed by American machinery was noted at that time. The comments of the foreign press on the Exposition of 1873 are of a like character; for example, *Engineering* (London, August 29th), under the head of Machine Tools at the Vienna Exposition, speaks as follows: "Leaving the American collection, and passing on to the British section, we cannot but be struck by the different character of the exhibits. In the American department almost every tool possesses some novel feature, and each is distinguished by an individuality which shows it to be the special design of its maker; while in the British section the great majority of the tools are reproductions of the old and well-known patterns, possessing scarcely any interest whatever as exhibits." Describing in detail certain English tools, mention is made of "one of Sellers' planing machines, with the driving pulleys arranged at right angles to the position given to them by Messrs. Sellers themselves, and some Sellers' screwing machines." Regarding this planer we shall have more to say hereafter. Again, in speaking of some Swedish machines, the writer says: "These tools are well made and of good design, but the patterns have a strong appearance of having been, to some extent, copied from American originals. The counter-shaft of the lathe, we notice, is carried by hangers of Messrs. Sellers' type, and in place of shifting the belts, friction clutch pulleys, of the pattern made by the Brown & Sharp Manufacturing Company, of Providence, U. S., are used for stopping and starting. In pointing out these facts we by no means desire to disparage Mr. Munktell's exhibits: the expedients adopted are good, and they deserve to be used in Sweden as well as in America." Although a high order of merit is thus recognized in all the exhibits of American tool makers, the special honor conferred upon William Sellers & Co. leads us to take their work as a prominent example of American ingenuity, and as showing something of the influence it is likely to exert in the world at large. To aid us in considering this subject, we have before us an illustrated catalogue of machine tools, entitled—"A Treatise on Machine Tools as made by William Sellers & Co., Philadelphia." This work, a neat duodecimo, is profusely illustrated by photographs and wood engravings, and contains not only a description of the various machines made by this firm, but also many of their ideas in regard to the use of tools and the general management of shops.

An examination of this book, in connection with the Vienna award

to this firm, and the favorable comments of our foreign contemporaries abroad, seems to call for more than a mere passing notice.

To make any machine of even moderate complexity, machine tools such as lathes, planers, drill presses, &c., are essentially requisite. All branches of mechanical industry are dependent upon the machine tool builder for their possible existence, save in the crudest form. Without machine tools, the steam engine and the power printing press would be impossibilities; and without them modern civilization could not exist. In the manufacture of these important tools, America seems—if we may judge from the flattering comments of the foreign press, and the increasing market which American tools find abroad —to be taking the lead, and that apparently because of the peculiar excellence of principle and novelty of design exhibited by American machine tools.

This fact, in view of the greater experience, cheaper labor, and ofttimes better facilities of the European manufacturer, seems, at first, contrary to what ought to be expected; and we are led naturally to ask the reason for such remarkable inventive activity in this particular direction, among American mechanics. A little thought, however, may show us that one of the most important reasons for this may be found in the very fact that with us wages are high and materials costly. Mr. Thos. Brassey, M. P., in his recent treatise on "Work and Wages," shows that in those countries where the working classes are paid the highest wages, the greatest mental effort is usually made to devise mechanical expedients to diminish more or less the necessity for purely manual labor,—not for the purpose of saving the laborer, but to enable each workman to produce more and better work than if unaided by such machines. Mr. Brassey also shows, by numerous examples, that, in spite of the high wages paid to American workmen, the work they accomplish not only costs no more than similar work done in the countries of cheaper labor, but that the actual cost is often much smaller. The true secret of American progress in the domain of tool building is thus really to be found in the great cost in America, of labor and material—a cost so high that it forces the manufacturer who would be successful, to employ to the best advantage every hour of labor, every pound of iron and coal. This fact coupled with American energy and enterprise is sufficient, we think, to account for American success.

Indeed, the very principles and theory of American machine construction bears witness to this; no opportunity is lost to save a use-

less step, an unnecessary motion. Writers on the subject remark that Americans try to arrange their machines so as to make them the most convenient for the workman. The planing machine for iron made by Messrs. Wm. Sellers & Co. is one of the tools that attracted the most attention abroad, and in referring to their book we find the following, in a description of this machine, extracted from the "Practical Mechanic's Journal," London: "Most conspicuous and important among the various novel features of this machine is the manner of giving motion to the table. This is furnished with a rack, but instead of being operated by the ordinary spur-gearing, it receives motion through a peculiar form of spiral pinion upon a driving shaft which crosses the bed diagonally, and passes out in the rear of the upright, on the *side where the workman stands.* (The italics are our own. ED.) This shaft is driven from the pulley shaft by means of a bevel wheel and pinion. The position of the pulley shaft *places the driving belt within convenient reach of the operator;* and its axis being parallel with the line of motion of the table, these machines may be placed parallel to lathes, and thus economize space and permit a better arrangement of the workshop." In noticing the Sellers' planer reproduced by an English house, as mentioned in our extracts from "Engineering," it is further said, it has the pulleys arranged at right angles to the "position given them by Messrs. Sellers themselves."

Nor is this all; one of our correspondents, an active member of the Franklin Institute, just returned from abroad, tells us that the pulleys are not only placed at right angles to the line of motion of the table, but on to opposite side of the machine, entirely out of reach of the workman. Struck with this apparently unaccountable change, he at once inquired its reason, and was told that the pulleys were so placed because British workmen *were used* to having pulleys put in this position. Here we see a clearly demonstrated advantage in an American invention set aside, as it seems to us, to satisfy the unthinking prejudice of the so called "practical workman." These workmen's prejudices always retard progress, and we fear are more likely than anything else to prevent a full appreciation of the spirit of American inventive genius in lands where tradition rules.

That American machine tools should be copied in countries where the art of tool building had its origin must be gratifying to their inventors; but if with these tools the spirit of enterprise of the American workman and his readiness to adopt all labor-saving contrivances could be carried abroad, no little good to the world at large might be

accomplished. This, however, must be a work of time, so radically opposed is the American system of well-paid, intelligent workmen to the English policy of cheap labor and forced ignorance—a policy that urges the reduction of wages to that minimum which will just enable the unmarried workman to procure the bare necessities of his cheerless existence.

Accounts continually reach us of the difficulty of introducing labor-saving machinery where labor is cheap and laborers ignorant.

If in our own land necessity compels the invention of labor-saving machinery, so does necessity compel its use; the labor element of population is not sufficient for the wants of the country, and the introduction of these aids to industry does not deprive a single man, woman or child of employment; but, on the contrary, it renders possible the utilization of unskilled labor, in the higher branches of mechanical art, at more remunerative wages. This seems to us happily expressed in Messrs. Sellers' book, in their treatise on lathes (page 69):

"It has been said that good workmen can do good work with poor tools. Skill and ingenuity may indeed accomplish great results; but the problem of the day is not only how to secure more good workmen, but how to enable such workmen as are at our command to do good work, and how to enable the many really skillful mechanics to accomplish more and better work than heretofore; in other words, the attention of engineers is constantly directed to so perfect machine tools as to utilize unskilled labor."

While we regret that American industries were not better represented at Vienna, we feel gratified at the praise bestowed upon what was displayed, and are justly proud of the prizes awarded to members of the Franklin Institute.

THE UTILIZATION OF COAL WASTE.*

The waste culm, or slack, as it is variously called, that accumulates in coal mining, has long presented a problem to economists and inventors. Great hills of this material arise wherever coal is brought to the surface, and these dingy hummocks have become as familiar a feature of Pennsylvania scenery as the wavy outlines of the tree-clad Alleghanies. The mountains of waste, moreover, are constantly growing, and their present cubic contents are estimated by hundreds of thousands of tons. As yet they simply represent labor lost. The best coal being in general more brittle, furnishes a larger quota to

* New York Tribune.

the waste heap than the poorer varieties, which are comparatively either soft or stony. In a recent paper read at the Bradford Meeting of the British Association for the Advancement of Science, Dr. Siemens, the well known inventor of the Regenerating Furnace, states the amount of coal left behind at the mine as waste, in English experience, as 20 per cent. of all that is extracted.

Inventions usually run in grooves. There have been many patents taken out, and a very considerable number of processes actually introduced in Europe and this country to utilize coal waste, but they can mostly be classed under two heads: (1) Burning the waste in a hot blast; (2) mixing it with some adhesive material and forming it into lumps. The first of these processes is, of course, only available in certain manufacturing operations. It requires for complete success the further reduction of the waste to an impalpable powder, and otherwise than experimentally has rarely been attempted. It is with the second class of processes that we have to deal. They have met with more success abroad than here, partly because employed with bituminous coal, and partly because the cost of labor and of adhesive materials proves with us a most formidable obstacle. In some European processes adhesion is obtained by mixture with gluten. Starch is named in one of the Belgian processes. Coal tar or its derivatives are specified in a large proportion of the patented mixtures. Rosin is used in one and shellac in another process, each of which has received commendation. Tan bark, saw-dust and peat are among the substances not unfrequently added, to give bulk and to make the compound readily inflammable, and as thus prepared its use is advocated for kindling as well as for fuel.

There is on exhibition at the Fair of the American Institute in this city the model of a machine for producing an artificial fuel belonging to this general class of inventions, but which in many respects surpasses anything hitherto devised. Most of the processes successful in Europe with bituminous coal fail here when applied to anthracite. The former supplies, when fired, a certain amount of bitumen, which helps to hold the artificial lump together until it is coked, while with anthracite the binding material, if inflammable, is soon burnt out, and the lump falls to pieces, dropping through the grate before the coal is consumed. If, on the other hand, an incombustible adhesive material is employed it may occasion a new difficulty. Silicates have been tried, but they form slags and clinkers by their fusion. The binding material of the invention under consideration is neither

combustible nor fusible. This material is clay. So far, however, there is little novelty, for the use of clay has not been unusual in these mixtures, but it has been in general combined with resinous or bituminous materials, its shrinkage in heat being set off against their tendency to swell. But in those inventions it was necessary that the coal be washed, dried and heated, and the cement kept liquid by heat. As, when such fuel was used, the cementing material gave off smoke and bad odors, a further process was found necessary to expel the volatile portion of it by carbonization or coking. It will easily be perceived that all this added largely to the expense of the artificial fuel. The process before us dispenses with the use, for adhesive purposes, of bituminous or resinous material. The only cement used is common yellow clay, with the addition of some milk of lime; *i. e.*, water carrying five per cent. of lime.

At an earlier period in the history of this invention it was scientifically tested by the Committee on Science and Arts of the Franklin Institute, Philadelphia. At that time, the inventor, Mr. E. F. Loiseau, of Mauch Chunk, Pa., added to the waste about seven per cent. of clay; he now uses but five. His fuel was then compressed in cylindrical molds; he has since improved its form. But the other features of the process, the use of the milk of lime, and the waterproofing of the surface of the lumps by immersion in a solution of rosin, remain unchanged. The report, dated December 19, 1871, is exceedingly favorable. Samples immersed in water for twelve hours, when broken for examination were found dry in the interior. Comparisons were made with a moderate and also with a strong draft. The percentage of ash was somewhat larger than with ordinary fuel, but was of a heavier and more cleanly character. The artificial fuel made with anthracite waste evaporated on the average to one pound of fuel 6 85 pounds of water; the average for pure anthracite is one pound of coal to 7·40 pounds of water. One pound of artificial fuel made of bituminous waste evaporated an average of 10·99 pounds of water; the average for bituminous coal is 14·88. The ability of the artificial fuel to endure transportation was then estimated as not equal to the best of coals, but superior to many varieties brought to market. The cost of manufacture at the mines was at that time about $1 per ton; it is now 85 cents. One day last week a considerable quantity of this fuel was thrown into the furnaces of the main boilers that supply engine power for the Fair of the American Institute. The intention was merely to exhibit its general characteristics. Each

lump being varnished with rosin, it could be handled without soiling the fingers. It burned steadily, holding its shape without disintegration, till reduced to ashes.

The machinery for manufacture as exhibited in the model dispenses entirely with handling the materials. The clay is poured in through one hopper, the coal-dust through another, the substances falling into equally revolving partitions on two separate shafts, the partitions that take the coal waste receiving and delivering exactly nineteen times as much as those that take the clay. As the coal and clay fall together they are sprinkled with milk of lime, which the machinery delivers in due proportion. The moistened mass is carried by a screw propeller into the mixing machine. Careful study of previous inventions and a long course of costly experiment had convinced Mr. Loiseau that many previous failures had been due to imperfect mixing. In this machine seven upright shafts, each carrying four toothed arms, cross one another, moving in different directions, and effect a thorough mixture. There is a very ingenious contrivance by which each shaft can be lifted and cleared without displacing the rest, in case a stone or other obstacle chokes the machine. The plastic product is forced thence by a series of knives and a screw propeller arranged on a central shaft, giving a pressure of several tons to the inch, through an aperture, upon molding rollers which receive it in ovoid cavities. From these the lumps are delivered in shape and size like hens' eggs. This shape was adopted as the result of many considerations and experiments. The lumps had been made in cubes, but these falling together with flat surfaces in the furnace did not permit free passage of air between them. A similar though less forcible objection was urged against cylindrical forms. The egg shape gives the greatest possible spaces between the lumps.

It should be mentioned that there are simple but effective contrivances for enlarging or diminishing the aperture of delivery to the molds. Leaving these, the lumps are carried on an endless belt into the drying chamber, where the belt revolves over rollers which reverse its direction and turn the lumps over several times, until, at length, sufficiently dried but yet hot, they are dropped into the buckets of an elevator and lifted to another endless belt, which carries them into a bath of rosin dissolved in benzine. Several mechanical difficulties in the process of a minor character are here avoided by devices which we have not space to describe. The heat of the lumps assists largely in evaporating the benzine as they issue from the bath, and the dry-

ing is completed by passage on another endless belt in a box where a blower gives a powerful current of air, and where the lumps are carried back and forth and turned over as in the first drying chamber. From the blowing box the finished lumps are discharged by a chute to load cars brought beneath it, the chute holding the load as it accumulates until the car is ready to receive it. As we have said, from first to last no handling is required.

It would be a narrow view of this new industry to perceive in it only the prospect of enriching its painstaking and persistent inventor. The utilization of waste products adds to the wealth of the entire community. Especially is it a matter of interest where fuel is concerned, whose cost is not only an element in almost every manufacturing and commercial enterprise, but enters into the economy of every householder. While the industrial organization of England is shaken to its centre by an advance in the price of coal, we cannot contemplate with indifference an undertaking which promises to cheapen it in this country.

Franklin Institute.

Proceedings of the Stated Meeting, September 17, 1873.

The meeting was called to order, with the president, Mr. Coleman Sellers, in the chair.

The minutes of the last meeting were read and approved.

A proposed amendment to the minutes of the meeting held last May was read, and, upon motion of Mr. Cartwright, it was resolved to insert the same in the minutes of the September meeting. The following is the amendment in question, which refers to the subject of a discussion concerning the Committee on Science and Arts: "Mr. Orr rose in reply to Mr. Briggs, and in opposition to his proposition, he stated what he conceived to be the leading purposes of the Institute, and that he did not consider one of these to be the task of determining whether the inventions submitted to it were actually 'patentable' or not, but whether such were useful and creditable, in accordance with the spirit of him whose name it bears—the great utilitarian of his age. He appealed to the members to judge of the Committee of Science and the Arts from their own knowledge of its services, and closed by moving the indefinite postponement of the motion to abolish it, which was promptly seconded.

"Mr. J. C. Cresson then gave a lucid statement of the activity of the Committee through its career of forty years, specifying a few instances of its marked value, and emphasizing the peculiarly fair and catholic character of its construction, and giving it his unqualified approval. In closing, he requested Mr. Orr to withdraw his motion to indefinitely postpone, in order to permit a direct vote on the proposition of Mr. Briggs, which, being complied with, the motion in question was lost."

The Actuary then submitted the minutes of the Board of Managers, and reported that at their stated meeting, held September 10, 1873, donations to the Library had been reported as follows:

Charter and By-Laws and List of Members of the Institution of Civil Engineers. London, 1873. From the Institution.

Report of the Meteorological Committee of the Royal Society for the year ending December 31, 1872. From the Society.

The Flora of Norway, by Dr. F. C. Schübeller. From the University of Christiania.

On the Rise of Land in Scandinavia, by S. A. Sex. From the same.

Annales des Ponts et Chaussees for April, 1873. From the Editor, Paris.

Transactions of the American Society of Civil Engineers for March, 1872, and January 8 and 17, 1873. From the Society.

Map of the Straits of Juen de Fuca, and the channels between the Continent and Vancouver Island; showing the boundary line between the American and British Possessions. From the Secretary of State.

Report of the Commissioner of Education for the year 1872. From the Commissioner.

The Actuary likewise reported the meeting of the various Standing Committees, and presented their minutes.

On behalf of the Special Committee on the Horse Power of Steam Boilers, the Secretary read communications from a majority and minority, which were, upon motion of Mr. S. L. Wiegand, laid over for discussion and action until the October meeting.

The Committee on Conflagrations reported progress, and was continued.

The President then announced a paper entitled "An Elementary Treatment of Zeuner's Slide Valve Diagram," by Mr. Hugo Bilgram. The same will be found in the Journal for October, 1873.

Mr. Hector Orr followed with a paper describing Heyl's Paper Box Machine. The same is published in the Journal for October, 1873.